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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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NOTES AND COMMENTS.

Small Additions to Cast Iron.

The present position of the question of the influence of special elements on commercial cast iron has been aptly summarised in the last and current issue of the Journal in an article by Mr. J. E. Hurst. He lays emphasis on the fact that in conducting experiments of this nature cast irons of varying silicon content should be used. Another statement, with which we are in agreement is that any improvement in mechanical properties by the addition of small quantities of special elements is certainly not due to their ability to act as "deoxidisers," for, as pointed out, it yet remains to be shown that cast iron contains oxides. If the theory of selective oxidation as applied to steel is also applicable to cast iron, then the silicon would be removed before the oxygen began to associate itself with iron. Thus any blow holes in cast iron are due to gases trapped in casting. The effect of these small additions is usually to be found not to deoxidise or degasify, but to modify the normal condition of the carbon. Thus it is desirable that a definite composition should be established as representing commercial cast iron. This, undoubtedly, presents many difficulties, as what would be considered "commercial" by the manufacturer of stove grates would be considered as "outside the pale" by foundries specialising in cylinder work.

Perhaps if experimenters bore in mind, that the best properties of cast iron are revealed by the annealed malleable variety, which are due entirely to the presence and distribution of temper carbon, and that the Americans hope in the future to cast malleable iron direct from the cupola, they might advisedly take their basis for commercial cast iron as one suitable for malleable work. The aim would then be to find an element, which when associated with well-defined casting temperatures and speeds, would precipitate the carbon in its most useful form as temper carbon. Then, perhaps, a short heat treatment to break down casting strains should be added. Unfortunately, the elements so far experimented with, seem to possess the opposite property, that is, they tend to keep the carbon in the combined form. A quarter of one per cent. of titanium was found by Rossi to improve the tenacity of cast iron from 20 to 30 per cent., and the transverse from 20 to 25 per cent. This was accomplished by adding ferro-titanium to the ladle, but our experience with this alloy, when added to steel, showed that unless added in the furnace, it was liable to give hard spots, which showed up on machining, and due, no doubt, to its infusibility. Therefore, it can be assumed that it would be infinitely more dangerous when added to cupola melted cast iron.

Institution of British Foundrymen.—Annual Conference.

Owing to the industrial crisis the Council of the Institution of British Foundrymen have not yet been able to decide definitely the date of the annual conference, beyond that it shall take place during the second or third week in September. We trust that when coming to a decision, the Council will take into consideration the meetings of the Iron and Steel Institute in Paris during the first week in September and the Institute of Metals in Birmingham during the third week.

Oil Firing in Foundries.

Undoubtedly the coal strike should give a considerable impetus to the use of oil in foundries for firing annealing ovens and drying stoves, and perhaps even for the auxiliary-firing of the cupola. Some experiments, of which we gave a summary in our issue of May 19, showed that under Austrian conditions auxiliary oil-firing in cupola practise was found to be advantageous, both financially and metallurgically. Oil has never been popular with British engineers owing to the large fluctuations in price. This unpopularity would be largely removed if oil companies could standardise their price over a considerable period. Should such be the case, many existing extravagant coal and coke-fired furnaces could be quickly and economically changed over to oil-firing, which would permit of a much more exact temperature control. If oil-firing does replace coal and coke, the present dispute may turn out advantageously for some foundries.

Owing to the continuance of the coal dispute the production of pig-iron and steel in May was negligible, amounting only to 13,600 tons of pig-iron and 5,600 tons of steel. Of the pig-iron produced 2,800 tons were hematite, 3,400 tons basic, 6,900 tons foundry, and 500 tons forge.

XUM

Moulding Double Compartment Inspection Cases.

By A. B. SMITH.

These cases are a familiar sight, as they are used in connection with tramway systems.

The pattern is made in two halves, and is roughly about 3 ft. 6 in. by 2 ft. 3 in. by 2 ft., and necessitates the use of a three-part box. It is partly made by hand and partly by machine, a jar-ramming, for preference.

Moulding.—Fig. 1 shows the turnover board for the top section of the pattern, made of stout timber, and well battened on the bottom. The dotted lines show the position of the pattern and box.

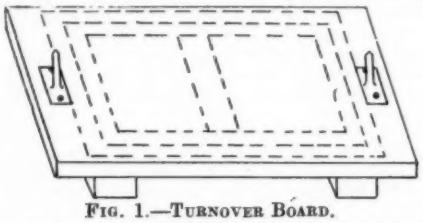

FIG. 1.—TURNOVER BOARD.

Two pins are attached at the side. The board is well bedded on the floor, and the rib pattern is placed on the board, the position being determined by dowels. Facing sand is sifted on the pattern before the box is put on. The grooves are now tucked with the fingers, and sprigs are put in at intervals of about an inch, a needle wire being used in the intervening spaces. The drag box can now be put on by means of the crane or overhead runway and clamped to the board, rammed up, and given a good venting. It is

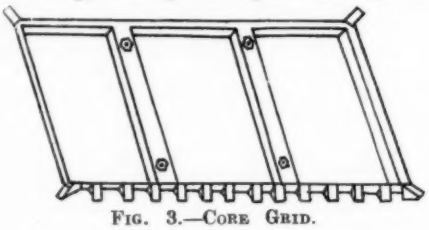

FIG. 3.—CORE GRID.

turned over into position on the floor, the board is removed, and the pattern can be withdrawn.

Ramming the Core.—In moulding this, the frame pattern (Fig. 5) is used together with any board or plate available. Upon this the frame is set, giving a simple job, no setting being required. A grid is used to lift the core when finished, and should be of the herring-bone type, as shown in Fig. 3. This has two or four nuts cast in equidistant for lifting purposes. A grid of this descrip-

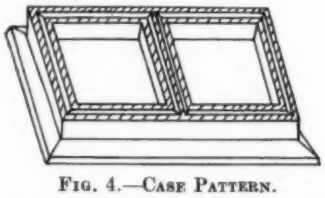

FIG. 4.—CASE PATTERN.

tion assists contraction, offering less resistance than a straight-sided grid. A thin layer of facing sand is sifted in, and the grid is well clay-washed and put in position, together with the screws for lifting purposes. These are rammed up in the job and afterwards act as vents. Facing sand is drawn up about half way of the pattern, and the body is filled in with sifted floor sand. The grid is well rammed all around and about half way up, when it is filled right up with floor sand, the ramming up being finished off with a shovel handle and struck off level. The loosening of the pattern is done with a block of wood and a hand hammer, thus the wood is held flat against the sides of the pattern while being rapped all round. The pattern is removed by means of the small holes in each corner of pattern. The core is now picked up by means of the lifting screws and chains, and guided on to and in position on the bottom mould, exactly matching and being flush with the insides of the bottom frame mould.

The case pattern (Fig. 4) is again placed in position on the first board (Fig. 1) to enable the outside mould to be made in the following manner. The pattern is set in position and the middle box put on. Now, owing to the wide flange it is necessary to have a frame bolted in as shown at "X," Fig. 6. This frame is made on the same principle as the grid, and with four lugs for bolting in. This is well clay, washed and rammed up completely, the joint being struck off at the top

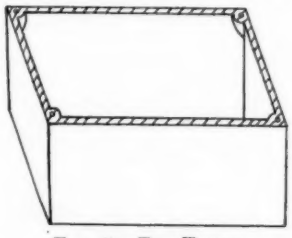

FIG. 5.—THE FRAME PATTERN.

as before and the pattern loosened in the same manner, but from the inside; the reason for not ramming up the middle and sides together is owing to the thinness and depth of the pattern, thus loosening is not effected at the four corners. Moreover, two labourers can be ramming up the cores whilst two other men are using the turnover board for the bottom moulds. The pattern being drawn, the runners are cut at opposite corners, the mould

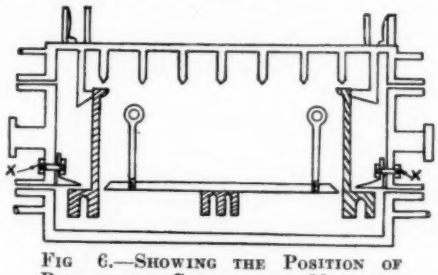

FIG 6.—SHOWING THE POSITION OF PATTERN AND GRIDS IN THE MOULDING BOX.

is picked up and placed over the core on to the bottom mould.

The top box is a plain flat top, readily made on any board sufficiently large, and assembled as at Fig. 6. When made in the foregoing method, it is an unskilled job, and, if a large jar-ramming machine is available, it can be utilised for most of the ramming.

The Birmingham Metallurgical Society.

Annual Report.

The Report presented to the members at the Annual General Meeting (Mr. A. Spittle, President, in the chair) at the Birmingham Chamber of Commerce, showed that the Society's activities during the last session had been progressive. The membership at that date had reached the total of 874, showing a net gain on the previous session of 44. During the session, 11 papers had been read before the Society, of which five had been given by members, and these had all proved interesting and of scientific value. The Society had maintained its progress and organisation without having recourse to increasing the subscriptions, and next session a branch will be inaugurated at Wolverhampton which will have an additional syllabus of lectures, etc.

The second annual award of the Society's Bronze Medal and Prize was made to Mr. C. W. Yearsley, Burslem, for his Paper on "A Physico-Chemical Interpretation of the Effects of Strain upon Metals."

The President elected to the chair for next session, is Mr. F. Johnson, M.Sc., A.I.M.M.; Mr. F. J. Cook was elected a Vice-President. The following members were elected to the Council: Mr. W. R. Barclay and Mr. E. A. Smith (Birmingham), and Mr. C. Carter and Mr. L. P. Wilkes (Wolverhampton).

National Physical Laboratory.

According to the Report of the Executive Committee of the National Physical Laboratory for 1920, the report of the Superintendent of the Engineering Department contains, as usual, an account of a large number of researches of general character, and of investigations carried out for external bodies or firms. Further results of interest have been obtained in the research on lubricants and lubrication. The measurements of skin friction near the surface of thin plates exposed to a current of air have been continued.

Progress has been made with the research relating to hardness and wear tests. The programme of work for the Notched Bar Impact Testing Committee of the British Engineering Standards Association has been completed and a final report presented.

The special investigations completed during the year include tests of a high-speed grinding attachment, tests on gas cylinders for the Gas Cylinders Committee of the Department of Scientific and Industrial Research, tests of worm gears and lubricants on the Lanchester worm gear-testing machine, and other work. A machine has been constructed for the measurement of the efficiency of power transmission through spur, bevel and chain gears.

Dr. Rosenhain, in his report on the work of the Department of Metallurgy and Metallurgical Chemistry, gives an interesting account of the more recent developments which have occurred in the various important researches in progress. A large amount of work of a fundamental character has been done in connection with light alloys, especially that directed to the study of the constitution of ternary systems containing aluminium, and the attempt to obtain a theoretical explanation of the special mechanical behaviour and of the microstructure exhibited by these alloys.

A Paper describing cases of cracking occurring in boiler plates was presented to the Iron and Steel Institute at the autumn meeting in Cardiff in September last. In order to carry the matter further, a series of experiments has been begun in which small samples of mild steel of various carbon content and in various conditions of heat treatment are exposed to continued stress while contained in a large electrically-heated oven, which is maintained at a temperature in the neighbourhood of 300 deg. C. It is hoped that at this temperature the phenomena of inter-crystalline separation may be accelerated and, by keeping the specimens in question under observation and noting the times and loads under which they fail, and their mode of fracture, it is expected that much light will be thrown on the manner in which steel may fail under such conditions. The great fundamental importance of such an investigation in regard to the use of mild steel for many purposes where it is exposed to moderately high temperatures, and in other conditions where exposure to severe stress exists for long periods of time, is evident.

The work which has for a long time been carried out by the Metallurgy Department, in the investigation of cases of failure and defects occurring in steel, has brought into prominence a number of problems of a fundamental character in connection with steel which require investigation. One of the matters in question relates to the temperature at which steels of various carbon-content begin to melt when heated. An exact knowledge of the temperature of incipient fusion or of final solidification (" solidus ") of the iron-carbon alloys is of fundamental importance in regard to many problems arising both in the course of investigations in the laboratory and in works practice. An opportunity for commencing an investigation on this subject, on lines more likely to lead to satisfactory results than those formerly attempted elsewhere, presented itself when a Japanese metallurgist (Mr. Asahara) obtained permission to work in the Department for some months. Mr. Asahara carried out a large amount of preliminary work in the preparation of pure iron-carbon specimens and in examining their behaviour when heated to various temperatures in electric furnaces. The difficulties in securing complete homogeneity of the sample and in preventing the loss of carbon during the prolonged heating necessary to secure a satisfactory state of equilibrium proved to be much greater than had been anticipated. The work has, however, been carried far enough to show the manner in which these difficulties can be overcome. Since Mr. Asahara's departure the work has been continued, a modification of the graphite-ring furnace, however, being necessary to ensure the desired condition.

Among the steel objects which come under the notice of this Department for investigation in relation to causes of failure are a considerable number, mainly derived from aeronautical engines, consisting of special alloy steels, among which nickel steels and nickel-chromium steels are most prominent. Although a considerable amount of knowledge has been obtained in regard to the structure and constitution of these alloy steels, there is need for a fundamental re-investigation of the whole matter. This has been begun by a study of the constitution and equilibrium diagram of the iron-nickel alloys free from carbon. An exhaustive research on this subject has been completed, and a Paper on the subject was presented to the Cardiff meeting of the Iron and Steel Institute in September.

The amount of investigatory test work which has come into the Department during the period under review was much greater than in any previous time in its history, a circumstance which indicates the wider appreciation of the services which the Laboratory is able to render to manufacturers and others treating with technical difficulties. The most important pieces of work of this kind have been submitted to the Laboratory by various Government Departments, notably the Admiralty, the Board of Trade, the Air Ministry, the War Office, and the Home Office. The character of the work involved in these investigations covers a wide range, including such objects as reduction gearing for steam turbines, welded boiler plates, railway screw couplings, oxygen cylinders, and case-hardened worm gear shafts for heavy motor vehicles. A still larger variety of articles, covering a wide range of industrial applications of metal, has come in for investigation for private firms and individuals. Owing to the confidential nature of such work, however, more detailed reference to it cannot be made.

Considerable progress has been made with the preparation of analytically standardised steel samples in conjunction with No. 5 Research Committee of the Iron and Steel Institute. Some five batches of standard steel ingots, or billets, have been received from the makers, after careful analytical examination and acceptance as sufficiently uniform, both by the Laboratory and by the District Authority acting on behalf of the Iron and Steel Institute. Three of these standards have now been machined and a sufficient quantity of fine millings suitable for analytical samples have been obtained and carefully mixed. Samples of these millings have been sent to the co-operating analysts throughout the various steel-making districts, and their results are now being received and compared with those obtained at the Laboratory. It is gratifying to find that in the majority of cases excellent agreement is being arrived at. It is hoped that analytically standardised samples will be available for public issue in a few months' time.

TENDERS INVITED FOR URUGUAY.—A telegram from the Commercial Secretary to His Majesty's Legation at Montevideo to the Department of Overseas Trade states that the local authorities are asking for tenders to be presented by August 18 for the supply of a steel petroleum tank, capacity 8,000 to 8,500 cubic metres; a Worthington duplex type steam pump for oil; and 250 metres steel tubing, required for the State Electricity Works, Montevideo. The materials are to be delivered within four months of acceptance of tender. The purchasers will erect the plant. Local representation is necessary. Further particulars are being forwarded by mail, and will be available for inspection by United Kingdom manufacturers and exporters on application to the Inquiry Room of the Department on their receipt on or about June 17.

XUM

Correspondence.

[*We accept no responsibility for the statements made, or opinions expressed by our correspondents.*]

Motor-Car Cylinders.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—With reference to the article, entitled "Some Castings for Internal-Combustion Engines," which appeared in the June 2 issue of THE FOUNDRY TRADE JOURNAL, I am astounded at the methods and statements made by the two authors therein, inasmuch as they are entirely at sea with regard to this business, and with the cylinder in question in particular. I have been intimately connected with the motor cylinder trade since 1904, and the article is contrary to all facts.

Taking a few of the statements *seriatim*:—

"It is questionable if a water-jacketed cylinder on a machine is very advantageous, because most of the work is in making the cores, and hand work cannot here be eliminated."

The authors here are far from correct. We make any cylinder that comes along on the machine, if the quantity permits of the tackle, and always obtain better results in output and finish. Also, we make a good number of the cores by machine, and where castings have to be jigged it is the only way to success, as it avoids all rapping, with the result that all castings are to size; in fact, hand moulding is not to be compared with the machine for this job.

"But endwise moulding has for some unaccountable reason never been popular for this class of work."

This is the most glaring mis-statement in the whole article, as 99 per cent. of water-cooled motor cylinders are moulded and cast "endwise," and the writer has seen cast in the foundries here some 10,000 cylinders during this last year for the chief motor firms, all "endwise," and feels certain that most of our competitors use similar methods. We ourselves have here perhaps a hundred cylinder patterns from different clients, and only one is constructed in the manner advocated, and this is not fit to use, so is obsolete.

Casting "endwise" is by no means new to the motor industry, as 18 years ago what was then the premier motor firm had all their patterns constructed for moulding and casting vertically. You will therefore see that "endwise" casting of motor cylinders has always been popular, and, further, it is the soundest method to adopt for this job.

"It may be admitted, of course, that much jacket coring is more troublesome when a job is moulded on end." This is incorrect, as the jacket cores are much easier to make and vent and fix in the mould, as there are only two jacket cores for "endwise" and three for the other method; and there is much more work in the barrel and combustion head and port cores, also there are extra cores for the outside. The fixing of the jacket cores when moulded and cored-up vertically is very simple, as the bottom jacket cores rest on the print of the open top of the water jacket and requires no chaplets to carry it, and the top half of the shell core can be screwed down through it under the drag; also, the thickness of the barrels is correct, the barrels in the jacket boxes having no joint down the centre, whereas when cored-up horizontally there is always a tendency to get uneven thickness, also chaplets or other means of holding the shell cores must be adopted.

"But it is regrettable that more discrimination is not used in deciding on methods of pattern-making and moulding. A practice is adopted in a shop, and under no circumstances is it departed from."

With this I agree, and I should say that the authors have had most of their experience in other than motor cylinders, and are trying to adopt this practice here.

To conclude, I may say that we have now in our possession the identical cylinder pattern which is here illustrated—the Vulcan type V.E.3-1—and this is constructed to mould endwise; also several others for the same firm, all similar, and there have been thousands cast from same; and we are absolutely at a loss to understand why such methods are put forward when they are contrary to all sound practice, and altogether against progress as far as output and good castings are concerned.

With your permission I will forward to you for publication the photographs of the Vulcan patterns, which are self-explanatory.—Yours, etc.,

June 6, 1921. PROGRESS.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—We have read with a considerable degree of pleasure and satisfaction the copy of the criticism of the water-jacketed article, and believe that only good can come of such a discussion. This is a subject that has been too little discussed by the foundry press. Our critic is severe, but his experience, we think, while it may extend over many years, has surely been somewhat limited.

We do not suggest that a water-jacketed cylinder cannot be made on a machine, but we do say that moulding with the cylinders in a horizontal position is a very common practice, and the vertical method, which is practically universal with ordinary land or marine engine work, though not quite so common with locomotive work, has not been universally favoured by foundries doing internal combustion work. The authors had experience of such jacketed cylinder work sixteen years ago with two very large motor firms, and the method of casting vertically was certainly not in use then; further, an incident came to our knowledge about two years ago of a foundry which specialised in casting petrol and ordinary gas-engine work returning a pattern because they would not undertake to mould it on end. This was a firm which turned out a very large quantity of internal combustion engine work for the Government during the war.

The fact is that moulding-machine makers are exceptionally enterprising, and will undertake to design a machine on which anything can be moulded. The manager of one of these firms, in conversation with one of the writers a few months ago, when asked if they had ever made a machine specially suited for this work, said they had not, and he doubted if it would be worth their while. "Progress" does not say whether his firm are makers of machines or jobbing founders.

District practice has much to do with moulding methods, and when "Progress" describes as a glaring mis-statement the assertion that endwise moulding is unpopular, he should remember the facts.

In some respects vertical moulding is the best for most classes of work, and if "Progress" will re-read the article he will note that we say "endwise moulding, experienced moulders are agreed gives better results and sounder metal, etc."

Practice varies in accordance with the quantity of castings required, and also whether the engineering firm has its own foundry for the work.

The writers have had considerable experience in this class of work, but our experience has not been confined to it or to it in one district. We have no doubt "Progress" is right, if his 99 per cent. is used with reference to the firm with which he is connected. It may interest him to know that in America, where it is generally admitted that quantity production is more intensified than in this country, the customary practice is to cast these cylinders horizontally.

In conclusion, we would point out to "Progress" that we did not state that the pattern for the make of cylinder described was usually jointed across the diameter of the cylinders. We chose a design suitable for our purpose and put our experience into it.

We sincerely thank "Progress" for his interest in the article and for his criticism.—Yours etc.,

London. "SHAW & EDGAR."

METROPOLITAN-VICKERS, LIMITED, which is the name of the old British Westinghouse electrical engineering concern at Manchester, has secured a £300,000 order for turbo-alternators for Melbourne.

AN important ship-repairing contract has just been secured by Messrs. Smiths' Dock Company, North Shields. It concerns the British steamer "Patella," which has extensive damage chiefly to her bows. The vessel has arrived at the firm's works, and work was immediately commenced on her arrival, providing employment for a large number of workmen.

Queries Answered.

Chimney Caps.

N1.—Could any reader inform me as to the best way of making the chimney cap as shown in Fig. 1?—"YOUNG MOULDER."

N2.—The chimney cap (Fig. 1), as the coping on top of a high chimney is usually called, is made in segments and assembled in position. The number of segments that are used to complete the diameter depends on the size and the height of the chimney. The chimney cap we are considering is intended for a chimney of about 11 ft. external and 9 ft. internal diameter. The method of joining these segments is either by inside flanges or by lugs, and whether flanges or lugs are used they should be kept at least ¼ in. back from the face in order that the segments will fit reasonably well together. There are several ways by which such a casting may be made, but we may rule out a first-class pattern and core-box because of expense.

The cheapest way of obtaining a casting is to use boards. Four boards are necessary. The boards for the drag should be outlined as shown in Fig. 2, the dotted line indicating the shape of the board for sweeping on the thickness, while the cope boards are shown in Fig. 3, the dotted line again indicating the thickness boards. The boards may, as is usual, be quite short, being set to the correct diameter by using a gauge stick. The parts B and C might be timber thicknessed, but the remainder of the mould would be clay or sand thicknessed. The length of the segment may be determined by laying a template, such as is shown in Fig. 4, on the joint when sweeping out the mould. The ribs and end flange or lugs can be measured into position. The metal may be poured through the top flange.

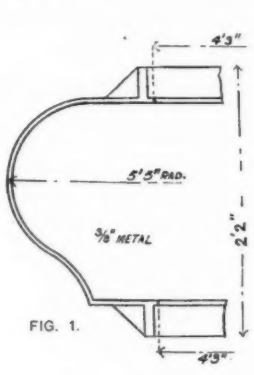

FIG. 1.

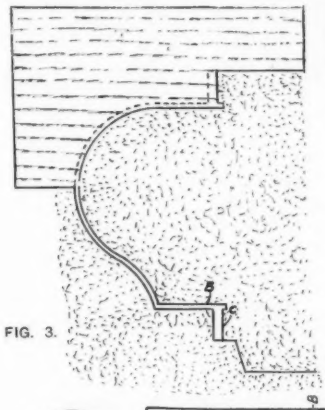

FIG. 3.

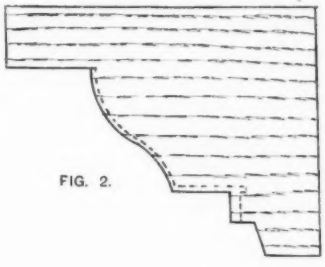
FIG. 2.

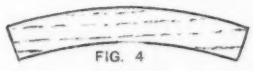
FIG. 4

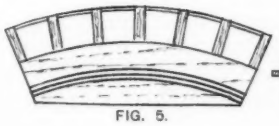
FIG. 5.

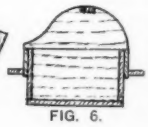
FIG. 6.

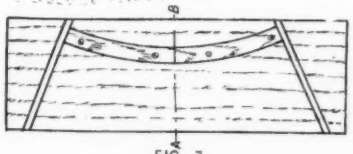
FIG. 7

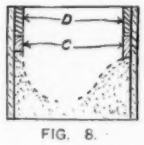

FIG. 8.

Whether the above is the best way is, of course, a matter of opinion, as eight castings are wanted, and the quickest way of getting them would undoubtedly be by using a pattern and core-box. Some foundries would make a skeleton pattern and thickness the mould. Neither pattern nor core-box need be very costly. The print should be about 1 in. thick at the ends of the core. The sketches Figs. 5 and 6 illustrate a suitable pattern, which is boxed up with sides and ends, with section pieces nailed on top. The core-box may be as shown in Fig. 7, which is a longitudinal section, Fig. 8 being a section on A B, and the dotted outline is of a strickle, which, bearing on the runners C C, really forms the core-box. After the bottom shape of the box is strickled, pieces D D can be fitted to complete it.

Another method that could be adopted is to sweep a concave bearance on which the flanges would rest, and a strickle could be used for sweeping the mould, a green-sand core being lifted in the cope.

Acid Resisting Bronze.

M 2.—In reply to Moulder's query, M 1, *re* acid resisting bronze, I would state that 90 copper 10 tin is very frequently recommended for mine water. The only difficulty with this is that it is almost never free from included oxides, and these cause rapid corrosion of the alloy, so that pure 88 : 10 : 2 is often used, the zinc acting as a deoxidiser. It would to a certain extent depend upon the power of the acid to be resisted and whether or not the seatings were to be hard. The gun-metal type of alloy 82 copper, 8 tin, 2 zinc, with about 8 per cent. of lead is a good mixture for parts which are not too large, otherwise they would segregate the lead and give trouble. An absolutely resistant alloy is Illium, with 62 nickel, 21 chromium, 5 molybdenum, 6.5 copper, 2 tungsten, and 1 each of iron, manganese, and aluminium, but it is difficult to cast soundly. Some of the things said to be good would not wear well, such as Retz' alloy, with about 5.4 per cent. of antimony, 8.9 per cent. lead, 11.4 per cent. tin, and 74.3 per cent. copper. The great thing is to melt without burning or stewing the metal, then not over-heat or cast at too high or too low a temperature, and with a good feeding head to ensure complete soundness. More often it is the perfectness of a casting which ensures the immunity from attack. J. S. P.

Holding Iron in the Cupola.

E2.—As the absorption reactions which take place between the coke bed and the molten iron are of an endothermic character, and this, coupled with the radiation losses, gives us grounds for believing that the iron loses some of its heat whilst in contact with the coke bed. This no doubt is the reason why all practical men advocate a well-ignited bed before commencing operations. The importance of this will be realised when red-hot coke is, say, 850 deg. C., whereas white-hot coke may easily pass 1,000 deg. We would advise our correspondent to take some pyrometric readings just before blowing, and plot these against the temperature of the first ladleful of metal. Then, having established a base, hold the iron for some little time. Naturally, the absorption of heat by the lining may mask the result, and so the experiment should be carried further, *id est*, when the heating of the lining has reached an equilibrium.

The Use of Borings in the Cupola.

C1.—With regard to the use of borings in cupola, I notice that "T. V." states that it is not necessary to use lime and water. I should be pleased if "T. V." would give us detailed account of the method used; for instance, is there any material or substance used as a binding agent, and are the borings then rammed up in boxes by hand or machinery? A description of the plant and method would greatly oblige one who is interested. H. C.

XUM

The Influence of Special Elements when added to Commercial Cast Iron.—Part II.

By J. E. Hurst.

Deoxidisers.

In the production of sound steel ingots free from blowholes it is common knowledge that the addition of comparatively small quantities of aluminium to the molten metal exert a remarkable influence in the production of sound steel. It has further been shown that the addition of small quantities of other elements exert a similar effect, and can efficiently substitute aluminium for this purpose. These elements have come to be known in the trade as deoxidisers.

The success of deoxidisers, when added to steel, has no doubt led foundrymen to investigate their influence when added to cast iron, and it has been urged, particularly by American foundry metallurgists, that the addition of small quantities of certain elements, such as titanium and vanadium, effect a marked improvement in both the mechanical properties of the cast iron and in the soundness of the resulting castings. The chief of these so-called deoxidisers are titanium, molybdenum and vanadium, and they are recommended to be used in the form of rich ferro-alloys. To this list the elements cerium and zirconium have recently been added.

The influence of these elements in improving the mechanical properties and promoting the soundness of cast iron is for the most part attributed to the influence in eliminating the dissolved gases, particularly oxygen and nitrogen, and in the majority of instances it is urged that comparatively small additions of the order of less than 0.25 per cent. are sufficient to effect this scavenging action. Some results published by various investigators are summarised in Table IV, and similar results are given by various other workers.

TABLE IV.—*The Influence of Vanadium on Cast Iron.*

Added Element.	Percentage Added.	Tensile without Addition.	Tensile with Addition.	Transverse without Addition.	Transverse with Addition.	Compress. without Addition.	Compress. with Addition.	Authority.
Vanadium	0.20	10.7 tons	14.25	Cupola	Metal	—	—	1.
	0.15	11.6 ,,	16.50	Air	Furnace	—	—	Kent Smith
	0.15	13.4 ,,	14.70	Air	Furnace	—	—	
	Not stated	5.5 ,,	8.70	Not	Stated.	—	—	
	0.15	Cupola	Metal.	2,200	1,300	—	—	
	0.15	,,	,,	1,900	1,400	—	—	
	0.15	,,	,,	3,400	2,500	—	—	
	0.15	Air	Furnace	4,200	3,700	—	—	
	0.13	,,	,,	4,400	4,000	—	—	
	0.15			—	—	60	67	
	0.15			—	—	65.2	71.5	,, ,,
	0.15	Chill	Cast.	—	—	96.0	112	

1. Foundry Trades Journal. Vol. XIV., Page 144.

Influence of Deoxidisers in Improving Mechanical Properties.—There is no evidence to show that the improved mechanical properties obtained by the addition of small quantities of these special alloys is due to their influence in removing the dissolved gases, particularly oxygen and nitrogen. It has never been satisfactorily demonstrated that oxygen exists in commercial cast iron, and, further, that its removal is accompanied by improved mechanical properties.

Experiments show that the principal gases existing dissolved in cast iron are hydrogen and carbon monoxide, and it is not suggested that the addition of any one of the special elements is capable of preventing the solution of these gases, and by this means improving the mechanical properties of the cast iron.*

The influence of any addition in modifying the properties of cast iron would, *a priori*, be expected to modify the amount and distribution of the carbon, and in the case of the element vanadium Dr. Hatfield showed, after an exhaustive investigation, that the influence of this element in preserving the carbon in the combined state was sufficient to account for the slightly increased strength values obtained as a result of addition of small quantities of this element. Investigations on similar lines do not appear to have been carried out in the case of the so-called deoxidisers other than vanadium, but it is legitimate to conclude that their influence on the strength properties must be preceded by some influence on the quantity, condition and arrangement of the carbon present in the cast iron.

Influence on Soundness.—It has never been suggested that the addition of small quantities of deoxidisers will correct unsoundness due to shrinkage, nor that due to the mould gases penetrating the rapidly solidifying iron. Nor, indeed, is it possible for additions of this nature to influence unsoundness due to these causes. The only other type of unsoundness remaining is that due to the liberation of gases dissolved in the metal whilst the metal is undergoing solidification. The enormous difficulties to be encountered in attempting to prove the influence of small additions of special elements in eliminating this latter type of unsoundness amongst all the others will be appreciated by all practical foundrymen.

It has been definitely shown both in connection with cast iron and also with other alloys used for casting purposes that unsoundness of this latter type is influenced very largely by the initial pouring temperature and the rate of cooling of the casting during the solidification period. In all experiments on the influence of additions of other elements on unsoundness it is essential to obtaining comparative results that these conditions of casting temperature and rate of cooling be identical throughout the experiments.

The author is not aware of any experiments which conclusively demonstrate the influence of small additions of special elements on the soundness of cast-iron castings.

It should be made quite clear to foundrymen that the conditions of unsoundness due to occluded gases are radically different in cast iron from those of steel, and there are no *a priori* grounds for assuming that the successful applications of deoxidisers to steel for this purpose are likely to be successful or even necessary in the case of cast iron. In the absence of large quantities of carbon, steel is capable of dissolving large quantities of iron oxide, FeO, which, reacting with the carbon present in the molten steel, evolves carbon monoxide gas. This is largely responsible for unsoundness in steel, and the addition of deoxidisers, by eliminating the dissolved FeO, serve to correct the unsoundness which would otherwise ensue. Cast iron, on the other hand, is incapable of dissolving FeO, and any unsoundness in cast iron must therefore arise from conditions different from those operating in the case of steel.

Some notes on the influence of the elements generally classed as deoxidisers are given below.

Boron.—Experiments conducted in Germany* showed that the addition of even small quantities of this element to cast iron tended to prevent the formation of graphite. Alloys containing 0.2 per cent., 0.4 per cent., and 0.8 per cent. of boron were prepared. With 0.4 per cent. boron it was found that the alloys were hard to machine, whilst the 0.8 per cent. alloy was so brittle that it could readily be pounded in a mortar. The silicon content of these alloys is not stated.

* N.B.—Oxygen is found in cast iron which has been exposed to high temperature conditions in an oxidising atmosphere and in a condition technically known as "Grown."

* Stahl und Eisen. 1914. H. 1530.

The boron-iron system has been investigated by Hamnesen and Tschischewski.* A compound Fe_2B_2 was shown to occur containing 7.2 per cent. boron. A eutectic of this compound was found to occur at a concentration of 4 per cent. boron. With as little as 0.8 per cent. boron a eutectoid constituent is formed which is very similar to carbon pearlite, and has been named boron-pearlite.

Cerium and Zirconium.—The addition of these elements to cast iron in the form of ferro-alloys has recently been recommended by Moldenke.†

The low melting point of these alloys is claimed as an advantage over such alloys as ferro-titanium and ferro-vanadium, ferro-cerium melting at 1,180 deg. C., a temperature only slightly above that of the melting point of commercial cast iron.

The cerium group of metals are chemically exceedingly active, and have a strong affinity for oxygen. The heats of formation of the oxides of this group are on a par with those of aluminium and magnesium.

Dr. Moldenke recommends the use of 0.1 per cent. of cerium in cast iron. It should be pointed out that Dr. Moldenke, in discussing the use of zirconium, agreed that it would be more serviceable in the case of steel than cast-iron.

Titanium.—Many pig-irons are found normally to contain appreciable quantities of this element, and the occurrence of a compound of this element with carbon and nitrogen have been noted by several investigators. The author is not aware of any data regarding the influence of this element on the condition of the carbon in cast iron.

Vanadium.—The influence of this element when added to cast iron has been investigated by Dr. Hatfield. The results of his experiments show that additions of vanadium have a definite influence on the physical properties of cast iron, and as a result of a series of heat-treatment experiments Dr. Hatfield was able to prove that the vanadium tended to maintain the carbon in the combined condition and prevent the precipitation of graphite. This is sufficient to justify the conclusion that the slightly improved mechanical properties resulting from additions of this element are due to this cause.

The Addition of Special Elements to Cast Iron.—The conditions of the foundry melting of cast iron in the cupola furnace are not favourable to the inclusion of the majority of these special elements to the mixture of irons as charged into the cupola for melting. The risk of large losses due either to oxidation or to reactions by which the added metal enters the slag are too great to allow of their successful addition in this manner. It is therefore usual to attempt to add these elements to the molten metal as it issues from the cupola spout or after it is collected in the ladle.

TABLE V.—THE INFLUENCE OF SPECIAL ELEMENTS ON CAST IRON.

	Element added.	Load.	Modulus of Rupture.	Hardness.	
	Per cent.	Lbs.			
Boron ..	0.0	509	44.310	228	Campion
	1.0	638	60.230	214	,,
Vanadium	0.0	509	44.310	228	,,
	0.15	577	55.180	217	,,
	0.25	594	56.070	217	,,
Molybdenum	0.0	509	44.310	228	,,
	1.0	680	65.550	217	,,
Chromium	0.0	509	44.310	228	,,
	1.0	573	50.640	230	,,

In the case of the elements such as copper, aluminium, nickel, tin, cobalt, whose melting points lie within easy range of that of the temperature of molten cast iron and are readily obtainable in a commercially pure form, they can be added direct to the molten metal in the ladle. In all other cases the elements are added to the molten cast iron in the form of ferro-alloys, most of which are now commercially obtainable.

The addition of ferro-alloys in this manner has the disadvantage of abstracting a considerable amount of heat from the molten metal, and consequently cooling the metal. On this account it is impossible to add comparatively large quantities in this manner. The cooling of the metal can be avoided by the addition of the elements in the form of thermit mixtures, in which form a considerable amount of heat is generated as a result of the reaction set up. Thermit mixtures are essentially mixtures of powdered aluminium and the oxide of the metal desired. When these mixtures are heated to a sufficiently high initial temperature a reaction is started of the following type:—

$$2Al + R_2O_3 = Al_2O_3 + 2R$$

in which the desired metal is liberated with the formation of aluminium oxide. The liberated metal is immediately absorbed by the molten cast iron if the reaction is carried on in a mass of molten metal, and as the reaction is exothermic no heat is abstracted from cast iron.

General Conclusions.—From an examination of the data available regarding the addition of special elements to cast iron it is found that no extraordinary change in the mechanical strength properties sufficient to warrant the commercial use are likely to be attained by the addition of comparatively small quantities of these special elements.

The addition of certain elements in comparatively large quantities are likely to be of commercial value in special cases. For example, nickel chromium, tin, as indicated.

The extension of our knowledge of the influence of these special additions on the other properties of cast iron, such as resistance to corrosion, resistance to high temperature conditions, electrical and magnetic properties is very desirable, and also on the influence of these elements in the presence of varying quantities of silicon.

* Z.A.C. 1914, 89, 287.
† Amer. Fdrymn's Assoc., 1919.

Arc-Welding Aluminium.

In a Paper read before the Liverpool Sub-Centre of the North-Western Centre of the Institution of Electrical Engineers, MR. F. J. HEYES (Metropolitan Vickers Electrical Company, Limited) stated that he had attempted the arc-welding of aluminium, using the ordinary acetylene welding fluxes, without any success whatsoever, and he reached the conclusion that it is essential to use a flux which is not easily vaporised. For this purpose he found cryolite suitable. Cryolite alone was no use for oxy-acetylene, as in that process the aluminium was only heated up to the melting point of the metal, and as the cryolite was only viscous at that temperature it would not allow the molten surfaces to come together, and no weld could be made. On the other hand, in arc-welding, a small pool of molten aluminium was formed at the point being welded, the temperature of which was far above the melting point of the metal, some of the aluminium being deposited in the form of vapour. At that temperature the cryolite became quite fluid and ran freely on the surface, enabling a very good weld to be made. In trying to weld with a plain electrode the aluminium hung in globules at the end of the electrode, and there was still a tendency for this to occur when using cryolite alone. A small percentage of chloride, however, overcame that difficulty, and rendered welding much easier. In acetylene welding it was recommended to use a rod of aluminium containing the flux.

As the acetylene flame could be used to protect the heated surface, that was satisfactory for that method of welding, but in arc welding it was essential to have a coating of flux on the outside of the electrode, as otherwise the aluminium in passing from the end of the electrode to the work became so thickly coated with oxide that a very large quantity of flux would be required to deal with it, and that would be very unsatisfactory. Where the electrodes might be subjected to rough handling it would be desirable to have the flux enclosed in the electrode, but as that was impossible it became necessary to fix flux on the outside of the electrode. That might be done satisfactorily with a binding of fine cotton. In welding iron or steel a current of about 80 amperes was required for a plate about one-quarter of an inch thick: on the other hand, if one wished to make a weld in a similar sheet of aluminium satisfactorily it was necessary to use a much higher current—about 150 amperes. The only explanation offered was that aluminium was a much better conductor of heat than iron, and as it was necessary to keep the pool of metal at the point being welded well above the melting point, it was necessary to use a much higher current. When the plates being welded were cold it was impossible to make a weld with a much smaller current than 150 amperes, but if the work was preheated to about 400 deg. C. a good weld might be made with about 60 to 80 amperes. That bore out the above explanation as the melting point of aluminium being only 500 deg. C. it did not require so intense a heat to keep the point being welded above that temperature if there was only about 100 deg. C. difference between it and the surrounding portions of the material.

Impact Hardness and Wear of American Malleable Cast-Iron.*

By H. A. Schwartz.

There are many industrial applications of castings in which the structural detail, instead of merely sustaining a steady load of some specific character, is subjected to blows, shock, or repeated reversals of the applied stress. Unfortunately, the knowledge of the principle underlying the behaviour of a material under dynamic stress still is imperfect. A great deal of experimental work of this character has been done and the results published, but no method is as yet available for systematically correlating the data and deriving general principles.

Two general groups of dynamic stresses may be recognised. One of these results from impact or blows. In general such stresses are in one direction only and usually are of considerable intensity. They may be applied axially, either in tension or compression to the detail involved, or may be applied to a cantilever beam or to one supported at both ends. Occasionally the loading is even more complex.

The other group of stresses results from repeated, usually rapid, reversals of stress, sometimes of small magnitude, and usually through an extended period of time. The stresses in a rotating shaft acting also as a beam are of this character, as are also the stresses in the leaves of an automobile spring, those in the couplers of a train while in motion, and those resulting from vibration.

In the former group a mathematical analysis of the service conditions is almost impossible. The material usually is stressed beyond its elastic limit by each blow so that it is impossible to determine the stress distribution within the metal. Moreover, the energy absorbed by a given specimen before breaking is less if the energy is delivered by a single impact than if delivered by a series of equal smaller impacts whose sum is equal to the energy of the single impact required for fracture. If fracture takes place under a series of blows the energy absorbed depends on whether the successive blows are of the same intensity or increase in intensity with each succeeding blow.

Thus it is seen that practically no two cases are alike in practice and that the problem is so complex as to prevent generalisation of the results of different groups of tests by mathematical analysis.

Therefore it is impossible to furnish quantitative data to be used as a basis of computation for mechanical details subject to impact.

The comparison of the behaviour of several materials under impact is easier, since the tests of all can be made under the same circumstances and on geometrically similar specimens. To avoid the complication resulting from the cumulative effect of repeated stresses, each insufficient to produce failure, the experiment usually is designed to break the specimen at the first blow and to measure the energy absorbed in breaking by taking the difference in the kinetic energy of the system before and after failure. The tests so made on various types of machines do not give comparable data, the results differ with the design of the hammer, the shape of the specimen and its manner of support.

It is said that on the Charpy machine, which takes a specimen 10 millimetres square by 53.3 millimetres long, with a 45 degree V notch 3 millimetres deep at the centre, about 7½ ft. lbs. are absorbed in breaking a specimen of normal malleable cast iron. On the Olsen machine breaking a round cantilever specimen with a 45 degree V notch .122 in. deep, 1.10 in. from one end, and with the notch clamped even with the vice jaws holding the specimen and the hammer striking .625 in. above the notch, the indicated energy absorption in breaking is 13 ft. lbs.

Impact tests may also be made in tension. In such cases the test is made on a screw-end tensile piece, one end of which screws into the hammer of the Charpy machine. The other end of the specimen carries a yoke which strikes a fixed portion of the frame of the machine just as the hammer is at the lowest point of its travel. The dimensions are so chosen that the energy of the hammer is sufficient to rupture the piece.

Evidently, for a given material the energy to produce rupture varies as the cross sectional area and as the length of the specimen. Upon the area depends the resistance of the material to tensile loads, and the length is a factor, since obviously twice as much work is done in stretching a piece 2 in. long a given percentage of its length as in stretching a piece 1 in. long an equal percentage.

It is noteworthy that while in static tension a defect operates to reduce the strength rather less than in proportion to its area and the elongation considerably, in dynamic testing practically absolute soundness of specimen is required. If a notch or shrink exists large enough to reduce the area sufficiently to localise the stretch within its own length, the gauge length upon which the work is expended becomes only that of the shrink. This may readily be only 10 or even only 1 per cent. of the apparent gauge length, and the ft. lbs. absorbed if calculated on the intended gauge length would be only 10 or 1 per cent. respectively of the correct values. Care must further be used to see that the specimen increases in size immediately beyond the gauge length. Any stretch outside the gauge length erroneously credits additional energy to the specimen.

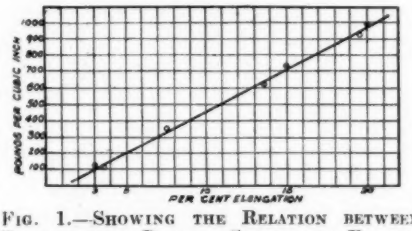

Fig. 1.—Showing the Relation between Resistance to Dynamic Strain and Elongation in Malleable Iron.

Sound specimens of good malleable iron 0.1 sq. in. in area and 2 in. long showed results as follows when tested:—

Energy of rupture (ft. lbs. per cub. in.).	Elongation (per cent. in 2 in.).
755	15
640	13½
999	20
930	19½

The relation between resistance to dynamic tension and elongation is plainly shown and is still more plainly visible by examining the following tests on good malleable containing small shrinks.

Energy of rupture (ft. lbs. per cub. in.).	Elongation (per cent. in 2 in.).
102	3½
115	3
345	7½

The graph in Fig. 1 which summarises these data indicates the almost direct proportionality of elongation and resistance to tensile impact even when the former is artificially affected by mechanical defects.

A normal malleable is supposed to survive 20 blows (aggregating 1,400 ft. lbs.) in this test and to break not more than 1⅞ in. from the thick end of a Walker wedge, which is shown in Fig. 2. In this test a wedge specimen 6-in. long by 1-in. wide, tapering from ½ to 1/16-in. thick, is used. The specimen is set on its thicker end on the anvil of a drop hammer and subjected to blows of 70 ft. lbs.

Professor H. F. Moore is quoted to the effect that ingot iron (ferrite) will withstand 100,000,000 repetitions of a stress 1.6 times its proportional limit, as determined in tension. This would indicate the probable great endurance of the matrix of malleable.

* Extracted from a recent issue of the "Iron Trade Review."

It will be seen that much remains to be done in the quantitative investigation of the resistance of malleable to fatigue and to impact. Fortunately, qualitative information of this character is readily accessible in view of the long continued application of malleable iron in the industrial arts. The practical experience which attracted consumers to this product when searching for a shock resisting material and in a period when methods of tests and metallography were practically unknown seems to have been well founded.

A logical reason now is available for this quality. Being largely ferrite, malleable is soft and ductile, as are all other materials in which ferrite predominates. Wrought iron is a conspicuous example of such materials; malleable is not as ductile as wrought iron because of the temper carbon present. Its resistance to deformation and shock, however, depend upon this principle.

Malleable has a further great advantage over many other materials in that the temper carbon granules, while of a form to affect the physical properties only to a relatively slight extent, operate as a hindrance to failure under alternating stresses by fatigue. Such failures frequently occur by the penetration of a crack between adjacent grains of the metal. When such a crack begins to form in malleable it does not penetrate far before it strikes one or more carbon granules. These stop its further progress just as a hole drilled at the end of a crack in a bell prevents the growth of the crack.

The best evidence available as to the shock-resisting qualities of the material are derived from the years of service which properly made malleable has given in draft gears, rail anchors, automobile hubs and spring brackets, car couplers

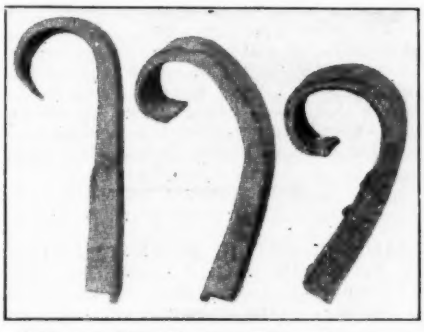

FIG. 2.—THE WALKER TEST WEDGE.

(until the high train loads forced the adoption of a material capable of higher unit stresses), and an indefinite number of similar applications.

For some kinds of service the fitness of a material for the use intended may depend not so much upon its strength under load as upon its machineability, resistance to abrasion, coefficient of friction, and similar properties.

The property which enables a material to resist cutting or wear is somewhat loosely called hardness. Unfortunately, this term is not clearly defined and often it is misinterpreted. Moreover, the commercial methods for measuring hardness in metals actually measure resistance to penetration under defined conditions—a property bearing no practical or theoretical relation to hardness as understood in the definition given above.

Two methods of measuring so-called hardness are in common use. In Brinell's method hardness is determined by the depth to which a 10-millimetre ball will penetrate under a load of 3,000 kilograms. In Shore's method, the rebound of a hammer falling from a fixed height measures, in effect, the work absorbed by the plastic deformation of the material under a standard load. The results of the Brinell test bear a fairly close relationship to the ultimate strength of the material, while the data obtained by the Shore method should conform to the elastic limit.

The Brinell number of normal malleable cast iron is from about 101 to 145 and increases, as does the tensile strength, with decreasing carbon. Common values are around 110-120. The scleroscope number also is somewhat erratic, running from about 15 to about 20. The strongest iron, having also the highest elastic limit, should have the highest Shore number. Neither of these numbers bears any particular relation to completeness of anneal. White iron is harder than malleable, so that the effect of annealing is to soften the metal under both tests.

Under commercial conditions, however, annealing is almost never so far from complete that this fact is of any value in inspecting material. Malleable castings, which are sufficiently annealed to pass any ordinary inspection, usually contain only very small amounts of ungraphitised carbides. The remaining combined carbon is either found as cementite in very minute grains scattered throughout the castings or as a thin layer of pearlite just under the surface.

The former condition would have no effect on the Brinell hardness and would affect the scleroscope hardness only if the hammer struck such a grain by accident. The thin sheet of pearlite does not increase the Brinell hardness appreciably, since the pearlite layer is merely crushed down upon the deeper material, which is soft. The Shore number may be affected by pearlite if this be present at the finished surface of this sample and if the layers are heavy enough to absorb the impact. Neither of these conditions usually exists, for the pearlite is originally covered with ferrite, and if in producing a finished flat surface for test any considerable amount of material is removed the pearlite layer may be completely destroyed.

Therefore, these tests are not directly applicable to the commercial valuation of malleable with reference to its cutting properties. The important considerations in industrial uses of malleable involve cutting hardness which is undesirable in working up the product in the machine shop, and wearing hardness or resistance to abrasion, which resists the destruction of a bearing or similar detail where subjected to friction.

These two conditions are different manifestations of nearly the same property. Ease of machining and resistance to wear are incompatible with one another. No direct means of measuring cutting hardness are known. The hardness of minerals is measured by comparison with an arbitrary scale ranging from talc, having a hardness designated as 1, to diamond, with a hardness of 10. Any given mineral can be rated by determining between which two numerals its hardness lies. Thus, pyrite, which scratches feldspar, hardness 6, but is scratched by quartz, hardness 7, is given an intermediate number, in this case 6.3. On this scale iron has a hardness of about 4 or 5 and steel a hardness of from 5 to 8.5. This test besides being very unsensitive can be applied only to the extreme surface of a metal. In the case of malleable this always is ferrite, which shows a hardness of 4.

Turner has devised a method based on cutting a line into the surface of the material. This is done by pressing the V-shaped nose of a diamond against the metal under a definite pressure. The cross section of the furrow cut, as measured by the width of the groove, is intended to be the measure of cutting hardness. This method is applicable only to the surface of an article. Since the surface must be smooth, it is difficult to apply this test to malleable containing a pearlite layer, as pointed out in the discussion of the Shore hardness. The test is not used extensively, and the writer knows of no data obtained from its application to malleable iron.

Similar tests, made by scratching polished samples and examining the scratch under the microscope, indicate that the hardness of the micro-constituent present in normal hard iron and malleable iron is in the following order: Ferrite, pearlite, cementite. Ferrite is soft and cementite nearly as hard as carborundum, as measured by resistance to scratching.

In machining malleable cast iron not much over 1/16 in. of material is removed at one cut. Only in rare cases are cuts of ¼-in. to 5/32-in. necessary in practice. The commercial speeds in lathe operation seem to run from 70 up to 160 or 170 ft. per minute. The heavier cuts usually are run at the lower speeds. Fine feeds are commonly used, ranging from .01 to .02 in. per revolution. Although generally these conditions are successfully met in operation, machining troubles sometimes are encountered. Therefore, there is definite reason to believe, either that there exists

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a fairly wide range of machineability in normal malleable or that in individual cases an abnormal product is unexpectedly encountered in a small amount mixed in with a large mass of normal material.

Smith and Barr have attempfed to determine the relative machineability of different samples of malleable and to compare the data with that for other materials. Their experiments were based on the torque required to cut threads into the different samples with two dies taken as standards and also by measuring the penetration per revolution of a standard drill under a standard load.

Unfortunately, the data are incapable of conversion into absolute figures. Smith and Barr apparently felt that they had secured evidence pointing toward the fact that iron high in tensile strength is relatively difficult to machine. The author does not feel that this conclusion is justified by the facts.

However, these investigations have accumulated useful data comparing the resistance to drilling of malleable cast iron, grey cast iron, and steel. Their results indicate that the penetration of a drill under standard conditions is at the rate of .249 in. per minute and .196 in. per minute in two specimens of grey iron; .209 to .240 in. per minute in 17 samples of malleable, and .052 to .085 in. per minute in three samples of steel. This proves the general thesis that malleable is comparatively easy to machine. An exhaustive study of all types of machining operations, using the best equipment known, is in progress under the writer's direction.

The machining difficulties occasionally encountered might be explained on any of three grounds. First, the material may be so tough that the heat developed per unit of time causes the tool temperature to increase rapidly. The tool fails for perfectly normal causes but under much accelerated conditions. Second, the material may contain particles sufficiently hard to work as an abrasive and so destroy the cutting edge. Third, the material may set up so heavy a tangential load in the tool point as to cause it to break off irrespective of the failure of the cutting edge.

A study of abnormally early tool failures seems to indicate the occurrence of failures of all three types. Since all malleable cast iron consists only of ferrite and temper carbon it is difficult to see how any great difference could exist between different products varying only in the percentage of temper carbon present. This is all the more true since in general the cutting is in a region where relatively little carbon remains due to decarburisation in anneal.

In the case of imperfectly annealed iron a condition accounting for any or all these causes of failure may exist. White cast iron is known to exert very heavy unit stress on the tool point, hence a metal so imperfectly annealed as to retain much of its original pearlite-cementite-dendritic structure would set up abnormal tool loads and cause a failure of the third class.

Material in which cooling has been so slow that all pearlite is graphitised but in which some cementite persists would produce failures of the second class. Cementite is an exceedingly hard ingredient, the hardest of any carbon-iron alloy. Its hardness on the mineralogical scale is between 8 and 9, since it is harder than the hardest steels. In imperfect malleable of this kind it would be found scattered as granules through the ferrite. Being present in very small amount only, it could hardly expect any very great effect on the ferrite mass in which it is embedded, and therefore is not likely to either increase the tool temperature or the load thereon. The tool edge, however, will encounter these granules lying in the finished surface, and these grains will rapidly wear away the cutting edge which rubs against them.

Failures of the first class are very largely due to so-called "picture frame" iron, in which there remains a considerable pearlite layer just under the surface. This layer is identical in composition and properties with annealed tool steel. As such its permissible speed will not be large before sufficient heat is generated to destroy rapidly the tool. Unusually bad cases of this character may also produce failures of the third class.

It should be remembered that all normally made malleable is easily machined, there being minor differences only between the machineability of malleable of varying composition. When machining difficulties are encountered the explanation generally is due to failures of execution in individual cases rather than to the character of the product as a whole.

To all intents and purposes, resistance to frictional wear obviously is the converse of machineability. Experience seems to indicate that the most successful bearing metals are those consisting of a fairly soft matrix in which a relative hard constituent is embedded. The hard constituent takes the wear and is supported by the soft. Further, the soft constituent wearing down a little, furnishes the certainty of a supply of lubricant to the bearing. The soft ingredient is further desirable since if a grain of abrasive enters the bearing and lodges tightly in the bearing metal it will soon cut away the rotating member where the latter rubs against it. With a soft bearing metal the grit will at most cut a groove in the easily replaced bearing without damage to the shaft.

Since malleable does not contain the hard skeleton or grain required to promote long life it cannot be regarded as a suitable metal to resist wear. By analogy also with grey iron this conclusion seems warranted. Extremely soft grey irons, which resemble malleable more closely than those containing more combined carbon, are inferior to the harder irons as bearing materials.

Malleable is not a suitable material of construction where the major requirement is resistance to wear. Determinations of the coefficient of friction for the metal are not available. While they would be highly interesting, they are not of great practical application because of the general unsuitability of malleable for friction service and because under normal lubricating conditions in machine parts there is not metallic contact between shaft and bearing. Therefore, the friction losses depend mainly upon the lubricant and not upon the material of the shaft and its support.

BAILY ELECTRIC FURNACES.—The Electric Furnace Company, Alliance, Ohio, announce the installation of three Baily electric brass melting furnaces of the resistance type at the works of the Bagley & Sewall Company, Watertown, N.Y., a 50-k.w. electric furnace with 500-lb. hearth capacity, the Alliance Brass & Bronze Company, a 75-k.w. furnace with 800-lb. capacity, and the Empire Brass Works, London, Ontario, a 105-k.w. furnace of 1,500-lb. hearth capacity. All of these furnaces are to melt yellow and red brass alloys. The Lorain Steel Company, Johnstown, Pa., is installing a 200-k.w. Baily electric furnace for heat treating railway bolts and similar parts. The furnace is of the continuous pusher type, with motor-operated control mechanism. It will be of sufficient capacity to heat treat 14 tons of material per day. Installations of electric heat-treating furnaces are rapidly increasing in plants which supply the railways with equipment such as axles, draw bar knuckles, bolts and similar parts.

SLAB HEATING FURNACES.—The E. W. Harvey Gas Furnace Company, Limited, of 70, Victoria Street, Westminster, have recently commenced the building for Messrs. David Colville & Sons, Limited, of four large slab heating furnaces with combined gas producers and coal feeding plant for serving a new plate mill at the Clyde Bridge Works, Cambuslang.

CANADIAN FIRM'S EXPANSION.—The Smith's Falls Malleable Castings Company, Limited, of Ontario, recently reincorporated as the Smith's Falls Malleable Castings, Limited, is contemplating doubling the capacity of its No. 2 plant, and provision has been made in its charter for the manufacture of steel castings. The company, which is the second oldest among the manufacturers of malleable castings in Canada, intends to install an up-to-date machine shop.

Electrode Electric Furnaces.*

By M. Gillot and M. V. Guillermin.

In the electric furnaces destined for the manufacture of steel, the transformation of energy into heat is made:—(1) By arcs striking between the electrodes and the charge, thus obtaining a direct heating at the point of junction of the arc and the charge, and indirect heating by the radiation of the arc and from the hot end of the electrode. Around the arc a very hot and very short flame produced by the carbon of the electrode contributes to the heating; (2) by the Joule (C^2R) effect in the charge traversed by the current, this disengagement of heat is particularly important at the points of contact of the scrap; (3) by the Joule effect in the hearth, where this happens to be conductive.

Whatever be the type of furnace employed, the heating by the arcs is by far the most important; it represents at least 80 per cent. of the expenditure of total energy.

It can therefore be said that the method of heating of the electric furnace is inferior to that of the Siemens-Martin furnace. In this last the flame is developed the full length of the chamber, and owing to frequent reversals, the heat of all the surface of the bath is relatively uniform, whilst in the electric furnace the sources of heat are concentrated under the electrodes, and this tends to give a bad distribution of the heat. This inconvenience is accentuated moreover by the high temperature of the source of heat.

These considerations impose then on the chamber of the electric furnace a form and dimensions different from those generally admitted for Siemens' furnaces.

The thermal distribution demands either a great number of arcs or a small surface of bath.

To reduce this beyond a certain limit will not only admit a very feeble contact between the metal and the slag, but also means adopting a great depth of bath and thus replacing a bad distribution of heat in the horizontal sense by a defective distribution in the vertical direction. On the other hand, as the number of electrodes cannot be indefinitely augmented, it is necessary to stop at a mean solution consisting in a furnace presenting a form of bath of deeper proportions than the Siemens' furnace and furnished with a convenient number of electrodes.

As a matter of fact, the greater number of furnaces actually working well, have a bath surface more or less equal to 1,200 sq.-millimetres per electrode.

For furnaces beyond 15 tons capacity, in which the external losses are very small it is possible to admit of a wider separation of electrodes, for example 1,800 sq. mm. of bath surface per electrode for capacities of the order of 30 tons. (Furnaces of 8 or 12 electrodes.)

The surface of hearth per ton charged is moreover less, accordingly as the capacity of the furnace is raised, but it ought not to fall below the following limits:—600 sq. mm. for small furnaces, 500 sq. mm. for furnaces of 6 to 15 tons, and 450 sq. mm. for large furnaces. These give entire satisfaction.

For the same capacities a less number of electrodes retards the operation and the heating; the melting at the banks is so retarded that it is constantly necessary to rabble the unfused portions towards the centre. This inconvenience does not exist if the furnace presents the characteristics indicated below unless there is a defect in the closing of the doors.

It is established, therefore, that furnaces of 4 tons with two electrodes and elliptic hearth, should be of 2,400 sq. mm.; furnaces of 6 tons with three electrodes and circular hearth of 3,600 sq. mm., and those of 8 to 10 tons of four electrodes with a circular hearth of 4 to 5 square metres.

Large furnaces ought to have such a number of electrodes that the masts of the suspension gear do not interfere with the melters' work. If the circular form is adopted it gives the least thermal loss. To make the electrode gear independent of the furnace body is to go back on the practice that has been indicated due to the necessity of tilting the furnace.

It would be much better, everything considered, to adopt a rectangular hearth for more than four electrodes, to arrange the charging door on one long side and to fix the electrode masts on the other side. It will then be of a similar form to a Siemens' furnace, easy for working and permitting mechanical charging.

The choice of a convenient number of electrodes is not alone governed by the necessity for rational heating, because there are other important advantages in melting.

Melting Conditions.—These are influenced by:—(1) The charge melts rapidly under each electrode, a hole forms in which the electrode descends by following the regulation for constant current; the pieces of metal forming the sides of these craters fall against the electrodes and give rise to short circuits; this is the principal cause of sudden overloads on the electric supply. It can be understood that the same amount of power divided between a greater number of arcs, on the same hearth surface, lessens these phenomena whilst giving a more equal melting.

(2) The fluctuations of one arc have so much less importance if there are more electrodes, because for the same proportional variation in the intensity of this arc, the perturbation caused on the other arcs and on the source of supply is more feeble.

(3) It can happen that damage to connections, to the suspension, to the hoisting mechanism or an electrode breakage can cause the suppression of an arc for a considerable time. The operation of the furnace can be completed so much more easily if the resultant loss of power is so much the less. In a furnace of two electrodes the rupture of an arc is equivalent to not heating of the charge while it lasts, for the thermal efficiency of two electrode furnaces is hardly more than 50 per cent. (either because they are furnaces of small capacity, or in case of large furnaces the arcs are badly proportioned).

Electrodes.—It is generally advised not to pass a current density in the electrodes of more than 5 amps. per sq. cm. if they are of amorphous carbon, and 16 amps. per square cm. if of graphite. In our opinion, the security of working of a steel melting furnace necessitates lower limits, being 3 to 4 amps. per $cm.^2$ for amorphous electrodes and 12 amps. per $cm.^2$ for graphite.

There are not made to our knowledge, graphite electrodes of more than 300 m/m. (12 in.) diameter. Steel furnaces cannot work with amorphous carbons of more than 450 m/m. (18 in.) diameter, because these electrodes need to be well shaped, homogeneous, and give a minimum of breakages. This limits them to the neighbourhood of 5,000 amps. for amorphous and 8,000 amps. for graphite for each electrode.

High densities cause important losses and considerable heating up of the electrodes. From this heating results a high consumption of electrode by oxidation and by breakage associated with a rapid deterioration of the electrode connections, etc. All this compromises the success of the operation, raising the cost of working and justifying independently of all other considerations, the increase in the number of electrodes.

In regard to all these advantages, the inconveniences of the increase of the number of electrodes are few; constituting practically a slightly weaker roof due to numerous holes, and the cost of installation, which is not augmented greatly; therefore, the only true inconvenience is the encumbrance of the suspension mechanism which can be reduced by a close study of the necessary strength and a judicious disposition of the masts.

The Sealing of Furnaces.—One question which must not be overlooked in the installation of an arc furnace is the sealing of all openings. A draught tends to be set up in the chamber of the furnace, the air entering under the doors and coming out charged with carbonic oxide (proceed-

* Extracted from the proceedings of the Société de l'Industrie Minerale.

ing from the reactions and the electrodes), in the space around each electrode. This results in the following inconveniences:—

(1) The cooling of the furnace in the neighbourhood of the doors where the fusion is retarded by the entry of cold air and also by the arcs being blown towards the centre by the gas current. (2) The changes in the atmosphere of the furnace which it is necessary to keep as little oxidising as possible during the deoxidation-desulphurising period under a reducing slag. (3) The wear of the electrodes causing deterioration of the electrode holders and the jib-arms when the electrodes are shortened; the gases coming out through the roof are, in fact, very hot, and ignite themselves when the operations are sufficiently advanced. (4) The wear of the circular openings around the electrodes, resulting not only from the temperature of the gas but also from the attack of the finely powdered oxides of iron and lime carried up. The enlargement of the openings diminishes the solidity of the roof and increases the draught.

The precautions necessary consist in the provision of tightly closing doors. Doors of sufficient weight, sliding on slightly inclined ledges which form grooves, can be used, or simple devices pressing the doors against their frames can be installed and the employment of economisers.

Economisers.—The economiser is an apparatus placed around the electrode above the roof, and assuring a sealing, more or less complete, of the openings without impeding the lowering or raising of the electrode. An objection is sometimes raised with regard to economisers being carried by the roof; but it is easy to suspend them from ties fastened to the roof frames with springs interposed in order to give only a slight pressure on the roof.

With the employment of economisers there results an economy up to two-thirds of the consumption of electrodes (and that is appreciable if it is remembered that in certain works the expenses on electrodes are of the same order as the expense in energy) there results equally a rise in the thermal efficiency of the furnace, the consumption per ton being lowered by 50 to 100 kw. hours.

Electro-metallurgical Considerations. — Constructed in conformity with the preceding ideas, the furnace has nevertheless a bad distribution of the heat in the vertical sense, which necessitates super-heating the upper part of the bath, making the operation longer, and thereby diminishing the thermal efficiency, and, above all, causing a chemical variation of the steel which even the operation of pouring into the ladle will not correct. This failure in homogeneity falsifies the conduct of the steel-making by the incorrect samples; it spoils the quality of metal cast, and that is even worse when the better quality steel is aimed for, especially when it is a question of the finer grades of steel for which a wide variation in the final composition cannot be permitted. It should not be forgotten that the electric furnace is the apparatus best qualified for the manufacture of high quality steels; therefore, perfect homogeneity of its product should be sought.

It appears that a great advance has been made in this direction by employing conductive hearths, which can be classed in two categories:—

1. The hearth with practically no resistance. Owing to the various means employed (metallic plugs, armoured sole) the return of the current to the transformers can be made by the hearth. It is then obliged to traverse the charge in the vertical sense, from which there results a Joule effect, important during the early stage of the melt when the contact resistance between the pieces is appreciable.

2. Resistive hearths in which, in addition to the above heating, further heat is generated in the sole itself. These will be referred to as "heating hearths."

The furnaces with heating hearths, which are more recent than those with non-resistance hearths, are less known and less advertised in France. They present, however, some undoubted advantages, and are employed in England, notably in the region of Sheffield, the producers of renowned steels, where the electric furnace has demonstrated itself as the victorious rival of the crucible.

In order that the heating of the hearth should have a useful rôle, it is not necessary that it should give heat to the bath and be at a greater temperature than the metal.

It is evident that all heat liberated in the hearth, thereby raising its temperature, in addition to the heating of the charge, diminishes the quantity of heat given by the bath to the hearth.

In fact, if at the beginning of the melting, heat passes from the hearth to the charge, whose temperature is relatively low, at the end of the operation the reverse is the case, and heat passes from the bath to the hearth, but the value of this heat is considerably reduced by the loss of heat in mass of the brickwork.

It is evident also that to obtain a good heating efficiency in the hearth, the heat losses through the bottom ought to be reduced as much as possible, and for this reason there must be incorporated:—(*a*) In the upper layers an electric resistance sufficiently high in combination with a satisfactory thermal conductivity; (*b*) in the lower layer an electric resistance practically zero, and a relatively low thermal conductivity.

Practically one is limited in heating the hearth by the fundamental condition of its preservation. Also with the refractory materials actually employed, one cannot think of expending in the hearth more than 10 to 15 per cent. of the energy consumed in the whole furnace; a current density of 0.2 amps. per sq. cm. cannot be exceeded. It is unnecessary to consider diminishing the thermal conductivity of the lower layers, which would give a high temperature in the brickwork. The amount of the energy expended in the hearth will then be fairly poor, but it is not necessary to attach importance to its exact value, for what is important is:—1. The raising of the total heat of the furnace in consequence of the reduced losses from the heating of the arcs. 2. The influence on the quality of the steel brought about by the homogeneity resulting from a better distribution of the heat.

Whatever may be the type of furnace adopted the making up of the heating hearth is fairly standard, and utilises the property that basic refractories (dolomite, magnesite) become partial conductors from 1,200 to 1,300 deg. C., accompanied by a rapid diminution of resistance as the temperature rises.

This electric conductivity is increased by the fine grains of carbon that the tar, the agglomerant, deposits during the making of the lining; it is reinforced by the incorporation of good conducting elements—graphite, carbon, steel filings.

The copper bars which lead the current from the hearth are placed horizontally in a bed of graphite and tar. Above this bed, essentially a conductor, are rammed successive layers constituted of magnesite and dolomite tarred, mixed with graphite and soft iron clippings. The proportion of these last constituents diminishes as the thickness of lining increases, becoming nil at some distance from the surface.

The conductivity of the deeper parts of the hearth can be increased by putting in well-cleaned soft steel bars, placed vertically in such a manner that the lower extremity is in contact with the graphite. The distance of the upper extremity of these bars to the surface of the hearth depends upon the electrical resistance to be obtained. The great care necessary for the construction of an ordinary hearth is no wise complicated. These hearths will stand before complete renewal more than one thousand casts; that is to say, they sustain an advantageous comparison which is due mainly to two causes:—1. The variations of temperature in the course of an operation are more slight than in an ordinary hearth. 2. The magnesite and dolomite thrown on the hearth for small repairs (being part of the maintenance of the melting chamber) easily takes hold, being subjected to the higher temperature of the upper layers.

It is only after burning in and heating to redness that the hearth becomes conductive; but after several heats the furnace can be left to cool without losing completely its conductability, and when it is again put into operation the current will pass immediately through the hearth. This is specially noticeable when steel has infiltrated into the upper layers of the hearth.

The resistance of the hearth diminishes as its life increases. It varies also in the course of one operation; at the commencement the steel scrap lowers its temperature, and the upper layers

become very resistive, the Joule effect is then important and contributes to the rapid melting of the charge, and that so much better as the point of heating is brought nearer the surface.

The operation advancing, the temperature of the hearth increases, specially in the higher parts, where the electric resistance diminishes so rapidly, whilst the deeper and cooler parts containing filings (of which the resistivity increases with temperature) have a very slightly variable resistance. At the end of the heat the Joule effect is then not only less important, but also less efficacious, seeing that the line of heating is lower.

This, on the contrary, is favourable to the life of the hearth, by avoiding a too high temperature in the upper portion.

It is feared that there are large Foucault currents (electro-magnetic) in the body of furnaces with conductive hearths, which diminishes the power factor and thermal efficiency. Practice shows that it amounts to nothing, and that the power factor varies from 0.80 to 0.90, as in other types of furnaces.

Moreover, the casing can be constructed in non-magnetic steel, which is rather dear; or more simply, interpose gaps between the plates by an insulator at the joints and the employment of sleeve-insulated bolts.

Certain constructors consider even these precautions useless.

There can also be realised the erection of a three-phase furnace with a conductive hearth and three upper electrodes, the hearth being connected to the neutral point of the transformer secondaries; but the hearth is traversed then by very feeble currents and only when the arcs are unbalanced in such a way that heating of the hearth is practically non-existent. If it is considered necessary to have three electrodes, the Nathusius furnace must be adopted, in which the neutral point of the secondary side is connected to the bath. Although the construction of the hearth is different from that of the furnaces above described, the Nathusius can be considered as possessing a heated hearth.

The electrical scheme ought to be conceived to obtain a satisfactory equilibrium on the system; that is to say, that when the intensity and power factor of the current are the same in all the electrodes, the current and power factor ought to be the same on all phases of the supply system.

This necessitates for the two-phase furnaces a hearth of very slight resistance, and for the three-phase furnaces of two electrodes, a transformer star-delta or delta-star having unsymmetrical windings, the equilibrium of the supply system necessitating a relationship of the nature:—

Voltage applied to the arc:—
Voltage applied to the hearth } for the one.

Resistance of the arc:—
Resistance of the hearth } for the other,

as in the Greaves-Etchells furnace.

The overload on the transformers and on the system resulting from a short-circuit between an electrode and the charge will be so much less the greater the resistance of the hearth. On the contrary, an increase in the conductivity of the hearth ameliorates, when the current varies in one arc, the perturbations caused in the other arcs. With a hearth of practically no resistance, except in the case of short-circuit, independence of the currents in different electrodes is practically realised.

In the Heroult furnace (three-phase) the alternating currents give rise to a magnetic field turning in a horizontal plane; in the furnaces with a conductive hearth of two- or three-phase and two electrodes, this magnetic field turns on a vertical plane. It may be remarked that this gives rise to a convection, drawing the deeper portions of the bath to the surface and contributing strongly to the chemical and thermal homogeneity of the metal. Towards the end of the heat, the metal being very fluid, the convection should be maximum, which should assure a rapid diffusion of additions. To our mind, this convection is very small, and it is not to this that the quality of special steels obtained in the heated hearth furnace should be attributed, but rather to the good distribution of heat during the operation.

Foundry Conditions in Sweden.

With exception for the time the lock-out lasted, the various steelworks in Sweden were satisfactorily employed during the whole of 1920. Compared with 1919 a considerable increase for the year was shown in the export of steel castings, the principal markets being Great Britain and Norway. Owing to the unfavourable exchange and German competition the sales to Denmark were insignificant. The selling price rose during the first half of 1920, but dropped later, so that at the end of the year it was about on the same level as at the beginning. The receipt of orders was very abundant during the first six months, gradually falling off, and had practically ceased during the last months of the year.

In comparison with the previous year the production of cast-iron hardware in 1920 was somewhat smaller, but the value of the output was, roughly, about the same. American and Swedish foundry pig was principally used, but toward the end of the year British and German foundry iron was also used, but in smaller quantities. During part of the year it was difficult to obtain foundry coke, especially during the late summer and autumn months, on account of the embargo and coal strike in Great Britain. During the last quarter, however, the Germans and the Dutch began to tender coke on the Swedish market, and the supply was ample during the last two months of the year. The prices of raw materials remained high during the first three quarters of the year, followed by a sharp drop in prices, especially for coke, which cost only about one-half of what it had been sold for in the autumn. Despite the lowered prices the average cost of raw materials for the year was no doubt higher than during 1919.

The demand for castings was exceedingly good during the first three quarters in consequence of the reduced output during the labour troubles and the difficulty to procure a sufficient number of moulders for several months. About one-fifth of the output was exported. The export declined rapidly, however, during the last three months of the year, from lessened inclination to buy in all markets. The import during the first nine months was not particularly noticeable, but toward the end of the year the German competition became troublesome, especially in regard to radiators, sanitary goods, and certain household utensils. The supply of orders on hand showed a considerable diminution during the last few months, and was very slight at the end of the year. The selling prices were increased in the spring in connection with the increased wage scale coming into effect.

Hollow-tube billets and hot-rolled tubes without welded joint were made by three and cold-drawn tubes by four Swedish ironworks. During the first nine months of last year, before the French tube works destroyed during the war had been rebuilt, the demand for high-grade tubes was very lively; but toward the end of the year the French works were started up and the demand fell off, while owing to German competition the export to Germany, Holland, Belgium, and other countries was also stopped.

MR. W. H. S. CRAVEN has retired from the board of the Lancashire Dynamo and Motor Company, Limited, and has been succeeded by Mr. R. E Hattersley. Mr J. G. Shaw, of the Crypto Electrical Company, has also been elected a director of the company

MR. NEVILE GWYNNE, late chairman of the executive committee of the British Engineers' Association, has been elected president of the Association, in place of the retiring president, Colonel O. C. Armstrong, D.S.O. Mr. E. W. Petter has been elected chairman of the executive committee, in succession to Mr. Nevile Gwynne.

It is reported from Hungary that by the initiation of the Stinnes group negotiations are proceeding with a view to the acquisition of the undertakings of the Rima-Murány Ironworks Company, the Schlick-Nicholson Engine Works, and the Ganz-Danubius Carriage and Wagon Works and shipbuilding yards.

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Aluminium in Motor-Car Construction.

The question of replacing cast-iron in the automobile industry by other materials has been touched upon in two Papers presented before the Sheffield Branch of the Institution of British Foundrymen during the last session. More light is shed on this subject by an article by Dr. Leslie Aitchison, which appeared in a recent issue of the "Autocar," of which the following is an abstract:—

In speaking of aluminium the word is often used to indicate a large group of materials, all the members of that group being more or less similar to aluminium in their nature and properties. Expressed briefly, the word aluminium is used to denote the whole class of "light alloys," fairly justly since these alloys have, almost without exception, aluminium as their base. The light alloys usually contain proportions of copper or of zinc (and occasionally both), whilst some of them, in addition to these elements, have also smaller proportions of nickel, manganese, magnesium, and iron. The proportion of these secondary additional elements rarely rises beyond 2 per cent., but the primary alloying elements may be present up to as much as 15 per cent.

The first property of aluminium which is of outstanding importance is its lightness. It is by far the lightest metal which is used in any notable quantity in engineering, and its specific gravity is, when commercially pure, about 2.75. Expressed in a more striking manner, if the weight of aluminium be taken as 1, the weight of a similar sized piece of steel would be 2.95, that of copper 3.32, and that of rolled brass 3.23. Compared with aluminium the weight of cast-iron would be 2.8. These figures require no explanation in order to make it apparent as to what are the weight-saving possibilities presented by aluminium. The alloys of aluminium, though not heavy, are scarcely so light as the pure metal, the specific gravity of the majority of them being between 2.85 and 3.0, that is, about 10 per cent. heavier than the pure metal in the extreme cases.

Disadvantages of Aluminium.—One reason why aluminium is not used more widely is its cost, though regarded on a basis of cost per ton it must not be forgotten that a ton of aluminium sheets contains nearly three times as many sheets as a ton of steel sheets of the same dimensions.

A second potent reason is the weight-strength ratio. Roughly speaking, steel is three times as heavy as aluminium, but at the same time it is, in the ordinary commercial forms of both metals, three times as strong. The advantage, therefore, of aluminium is apt to disappear when viewed in this way.

Strength of Aluminium.—As in most metals the mechanical properties of aluminium and its alloys depend very largely upon their condition, *i.e.*, whether the metal is in the cast state, or whether it has been drawn or rolled or extruded. So far as pure aluminium is concerned, it practically never appears in commerce in the cast state, but only after mechanical working in some form or other. Its tensile strength after this treatment varies with the amount of work that has been put upon it, and also depends upon the softening treatment, if any, which has been given to it after working. Annealed aluminium has a tensile strength of about 6 tons per square inch, whilst the half hard and the hard-rolled sheets of commerce have strengths of about 8 and 10½ tons per square inch respectively. For ordinary purposes it may be assumed that the greatest strength that can be expected in pure aluminium is about 10 tons per square inch. Now the lowest strength which is obtained from steel, even when it is put into its softest condition, is about 20 tons, *i.e.*, at least twice that given by the best pure aluminium. The ordinary run of steel sheet approaches to 26 or 30 tons per square inch, so that it has a strength more of the order of three times that of aluminium. If, therefore, a certain part is stressed to a certain value, the section of the part made in aluminium would require to be about three times as large as if the part were made of steel. As the steel would weigh about three times as much (for equal volume) the actual weight of metal used in each case would be practically the same.

Duralumin. — The above figures show that the utilisation of aluminium (pure) for stressed parts is necessarily limited by its weakness. The figures given only apply to pure aluminium, and much better strengths can be obtained from the light alloys—particularly those which are used in the rolled condition. One typical such alloy is duralumin, which is being produced regularly in a form giving a tensile strength of not less than 25 tons per square inch. This is not the only light alloy which will regularly give tensile strengths of over 20 tons, and, by virtue of the weight-strength ratio explained above, it gives the same strength—weight for weight—as a 55-ton steel.

Aluminium versus Cast Iron.—When the cast light alloys are being considered the most useful comparison is that which can be made with cast iron, since for automobile work steel castings are not used to any appreciable extent. When these two metals are considered there is very much less disparity between the mechanical properties. The tensile strength of cast iron is not very high—ordinary commercial iron running about 11 tons per square inch. A strength as high as this is easily within the capacity of some of the light alloys, whilst the majority of them give a strength of 8 tons or more. On the basis of the weight-strength ratio evidently there is here the possibility of a great saving. A similar benefit accrues from the use of aluminium in place of gun metal and many of the yellow metals from which castings are frequently made, as these metals are heavy and except in a few cases of no particular strength. To the automobile engineer there is therefore a great advantage in the use of aluminium and its alloys in the form of castings. The truth of this is seen in the increasing proportion of aluminium carburetter bodies, crank cases, pistons, timing gear covers, etc., employed.

The already widespread adoption of light alloys for automobile castings makes it reasonable to wonder why they are not employed for all such castings. Why, for instance, are not cylinders made of a light alloy? The answer to this question is not difficult to find, and the reason for the unsuitability of aluminium lies in its "softness" or poor resistance to abrasive forces. Although cast-iron is by no means very strong in tension and not conspicuously so in any direction, yet it is a metal which presents a good resistance to wear and to abrasion. This is explained by saying that grey cast iron is self-lubricating. Whatever the reason, the fact is certainly this, that if two cylinders, one made of aluminium or a light alloy and the other made of cast iron, are run under the same conditions, and with similar pistons each provided with cast-iron rings, the aluminium alloy will be worn out a very long time before the cast iron is appreciably harmed. This fact has led to the use of various devices to enable aluminium to be employed at any rate in parts for cylinders. The insertion of a steel liner is one such device. The use of a normal steel barrel jointed on to an aluminium-alloy water-jacket is another. In other examples (particularly in air-cooled engines) the cylinder head, which is not subject to abrasive action, is made of aluminium, whilst the body of the cylinder is made of steel.

Conductivity.—The use of aluminium or light alloys generally, for the water jacket of cylinders and for cylinder heads, brings forward another property of the metal which is of real value in engine work. This is its capacity for getting rid of heat. The value of the thermal conductivity of steel is 11.7, of brass 23.8, and of aluminium about 45, taking silver as the standard with a value of 100. Aluminium can, therefore, carry away about three times as much heat as is conveyed by steel. This fact in itself means that more efficient cooling may result from the use of a cylinder head made of a light alloy than from one made of cast iron or steel.

For the sake of completeness, if for no other reason, it is desirable to give an indication of those other properties of the metal which are in the nature of disadvantages rather than advantages. It is advisable to mention that the melting point of aluminium is rather low, being not much more than half as high as that of cast iron and about two-fifths of that of steel. The melting

point of the alloys is almost always a good deal lower. This fact only becomes of importance in connection with the use of the light alloys for those engine parts which are subject to sever temperature conditions—such as pistons, etc.

Porosity. — A more serious difficulty which is experienced with the light alloys is that of making thoroughly sound castings which are entirely free from porosity. It is not easy to manufacture castings in any metal which shall be entirely and completely sound, but perhaps this difficulty is greater with the light alloys than with any other group of metals. Porosity of the castings has frequently been overcome by treating them in various ways before they go into service. Such operations as boiling in linseed oil or soaking in a solution of water-glass under pressure go quite a long way towards the alleviation of the trouble induced by porosity, but obviously they do not overcome it. A trouble of a similar kind is the liability of aluminium and light alloy castings to develop flaws due to shrinkage and contraction incidental to the manufacture of complicated castings. The light alloys are particularly weak at temperatures near to their melting point (or solidifying point). The weakness is more pronounced in some of the alloys than in others, but it can easily be appreciated that in metal which has this fault the stresses which are set up during the course of the solidification of castings in a mould would tend to pull apart the constituent portions of the casting, unless the metal is able to withstand considerable stresses. The above two troubles are really subjects to be overcome by the scientific skill of the aluminium caster.

Corrosion. — Aluminium is not very readily affected by the ordinary corrosive actions of the atmosphere, but this must not be construed to mean that aluminium does not corrode. Aluminium corrodes fairly violently under certain conditions. So far as ordinary atmospheric corrosion is concerned the metal is certainly not particularly subject to attack, especially when in its ordinary commercial form. Under the influence of active corrosive agents, such as sea water or various other chemical solutions, aluminium will corrode fairly readily, and the aluminium alloys will corrode very readily—particularly those alloys which contain copper. This corrosion is excited somewhat if the aluminium or the light alloy is in contact with another metal, such as steel or one of the yellow metals.

It is important, therefore, that if aluminium or its alloys be used in constructions where corrosion is likely to have a serious effect, either as a result of the accumulation of the products of corrosion or by reducing the strength of the structure, some methods should be employed for the protection of the metal. It is not possible at present to suggest any really satisfactory methods of protecting aluminium by means of an applied metallic coating, such as can be employed for the protection of steel by zincing. The protection must be effected by means of some organic reagent, such as stove enamel, paint, or varnish.

Growth.—One of the principal objections which has been raised against the extensive use of aluminium alloys for engine parts such as pistons, in which the alloy is necessarily subjected to the influence of high temperatures, is the "growth" of the metal which is stated to occur in such parts. The growth of aluminium alloy castings when subjected to high temperatures has been carefully investigated. The results which have been obtained go to show that a small amount of growth does take place when light alloys are heated to temperatures higher than about 250 deg. C.

Growth is progressive and continuous, and is in accordance with the length of time during which the alloy is subjected to high temperatures. It is usually found that the maximum degree of growth has been reached after an exposure of about thirty hours. A further time of heating results in a slight contraction. The actual extent to which growth takes place even at the maximum is not very great. Apparently the permanent increase of dimension resulting from growth, is only about one-tenth as much as the temporary increase of dimension due to the ordinary thermal expansion which the aluminium alloy experiences when raised to the high temperature which produces the growth. Also, since with further heating the alloy contracts, it is probable that the final change of dimension rarely amounts to as much as this.

The extent to which a part made in a light alloy will grow can be diminished by subjecting it to heat treatment before finally machining. If the casting is baked for six or eight hours at a temperature of about 350 deg. C. prior to the final machining operation, the subsequent growth is very much decreased. Such a treatment has also a good effect upon one of the other causes of dimensional change. Without doubt a good many instances of what has been thought to be growth were really distortion due to the liberation of casting stresses and strains. Running in the engine releases these stresses and strains, and the casting consequently tends to change its shape. The change of shape will occur whether the heating of the casting results from the temperature attained by running in an engine, or whether it be produced by heating the casting prior to its being put into the engine. The baking suggested above has the effect of causing the distortion to occur before the casting is put into the engine. By such a treatment it is probable that the difficulties experienced from the change of dimension of aluminium alloy castings would be very materially lessened.

Having thus detailed the majority of those properties of aluminium which may be regarded as having the nature of defects, it is clear that none of those properties are such as to render aluminium less useful than the majority of the other metals. It has been shown earlier that aluminium possesses a number of very excellent and useful properties, and that these can be effectively set off against those properties of the metal which are not so obviously useful, the result being, when the balance is struck, that in aluminium the automobile industry has a very useful servant indeed, provided it be put to duties of a suitable nature

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

The Question of Apprenticeship.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In your issue of May 19 you call attention to what is a very serious position in the ironfounding industry—that is, of raising the moulder's position in the craftsmanship of the various branches of engineering. It is a matter that has called for the very earnest consideration of my Association, and we have tackled the matter by instituting an Apprentices' Class at the Newport Technical Institute. There are a very large number studying there for engineering, but none could be induced to take up moulding. After thoroughly discussing the matter we decided upon the following course for indentured apprentices:—The firms pay the lads' fees (£2 2s. per annum), the boys to have one full day per week holiday, and their time at school is reckoned as working time, and is paid for as if in the shop. The teacher reports absentees to the firms. We have started with the lads already in the shops, and they very much appreciate what is being done for them.

We consider that for many years the moulder has been looked down upon because his work is dirtier. Our opinion is that he is of full equal value to the engineer, and we want the lads to recognise that they have entered upon a career that is worthy of their best.

The subjects taught are mathematics, drawing, metallurgy, elementary chemistry.

We hope by-and-by to establish a practical workshop at the Institute, as under present conditions the class, which numbers 17, visit the various foundries in the district.

I think that this is the first practical step towards the realisation of your article. Our rates for apprentices are now 12s., 15s., 20s., 25s. and 30s. per week each year.—Yours, etc.,

F. J. MARSH,

Secretary of the Newport and Monmouthshire Master Ironfounders' Association.

191, Commercial Road, Newport, Mon.,
May 23, 1921.

XUM

Making a L.P. Cylinder in Loam or Dry Sand.—III.

Coremaking.

By "Ben Shaw" and "James Edgar."

Whether the mould for the cylinder is made in dry sand or loam, the making of the cores should proceed simultaneously with that of the mould, so that the various parts involved to form the complete mould may be ready as nearly as possible at one time. This factor is not always conceded the importance which it deserves. When the mould is ready and waiting for the cores, valuable space is being occupied without a return, and when the cores are prepared before the mould is ready for them, they occupy space in the ovens which either keeps back other work or causes the oven to become congested, involving additional

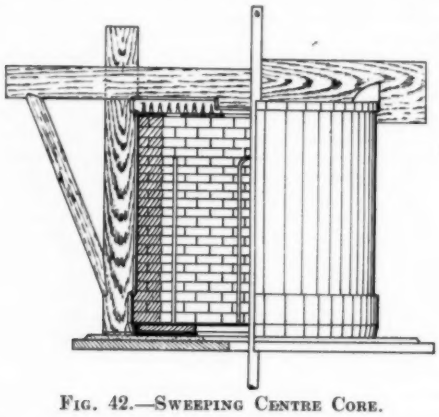

Fig. 42.—Sweeping Centre Core.

labour in moving work to and from the stove. Each foundry usually has some system in detailing the various operations necessary in the production of these cylinders, and the time occupied in making the casting varies according to the system adopted, the method of preparing the mould, the number of skilled men available—that

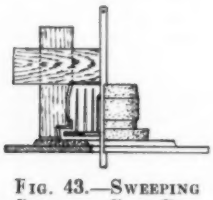

Fig. 43.—Sweeping Stuffing Core Box.

is, the number capable of being conveniently employed on the work—and the general facilities in the foundry for this particular type of work. When the mould is prepared in dry sand from a loam pattern the cores are usually prepared in loam on a special loam floor adjoining the sand floor, and, as the cores and runner involve more work than in the making of the mould, more men are frequently employed in their production.

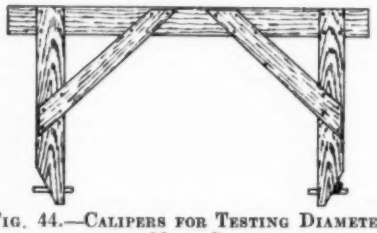

Fig. 44.—Calipers for Testing Diameter of Main Core.

The centre core is swept up in a somewhat similar manner to that already described for the loam pattern, but much greater care is necessary in setting the bricks, as there is a tendency to reduce the area of core space towards the centre of the core. The brickwork should be stronger, and sufficient area of loam should be allowed between each brick to enable gases generated when casting to escape towards the centre of the core, otherwise there is a possibility of having dumb scabs in the bore of the casting.

When the sweeping board has been set at the required distance from the centre and secured to the spider with the bottom end in contact with a prepared bearance, a layer of loam is applied into which a plate is bedded. This plate should be substantially made, having staples cast in it for convenience in lifting. The method of building is shown in Fig. 42, and when the top is almost reached another plate is required to be bedded over the brickwork to carry the loam forming the top shape. This plate need not be very strong, but

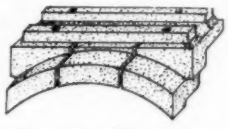

Fig. 45.—Port Core.

the hole in the centre should be as large as possible. Sometimes, though not frequently, the centre core is made to carry the core for the stuffing-box also as one core; it is, however, preferable to make these cores separately, then an enlarged print can be used to connect them, which allows the use of a larger hole in top plate of the main core. The volume of air in a large hollow core of this kind is considerable, and as this volume increases approximately five times during the time of casting, and it is supplemented by the additon of gases formed at the time, due to the heat acting upon the loam contents, it is

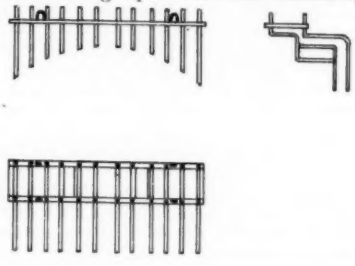

Fig. 46.—Grid for Steam-way Core.

good practice to reduce this space by lightly ramming in sand, and the larger hole in the top plate gives the moulder more room for that purpose. Reducing the volume of air by the introduction of sand is done after the centre core has been lowered into its position during the time of closing the mould. When the top of the core has been swept, the board is removed and a board attached for sweeping part of the steam-way core. It is necessary to mark the position off by means of the template provided for the purpose, the flat surface of the main core being cut away to allow a supporting grid to be secured to the top plate; the sweeping of this part can then proceed, the

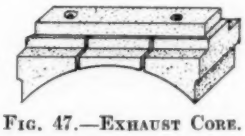

Fig. 47.—Exhaust Core.

two ribs being introduced during the process. A slight variance from this method is sometimes adopted; a seating may be swept out for the print, or, instead of it being tapered off as shown in Fig. 42, many foundries prefer to sweep it parallel and carry a fin on the casting. The sweeping of the stuffing-box core is comparatively easy. In this case a plate is used carrying a

number of gaggers, as bricks cannot well be used; hard loam is used with advantage in stiffening the loam so that it will carry. In sweeping each of these cores it is customary to allow them to dry a little before the final sweeping is given. Gauge irons cannot very well be introduced into the cylinder core as in the case of the loam pattern, so that it is necessary to caliper the core after it has been dried. For this purpose the wood calipers shown in Fig. 44 are of convenient form. They are usually adjusted by the pattern-maker, but the moulder should set them himself.

The making of the chest cores occupies much time, especially when the core-box supplied is made for the steam-ways and the exhaust together. The advantage of the method is the better prospect of obtaining a regular metal thickness between the compartments, but it causes more trouble to the moulder. The two steam-way cores are prepared first and strickled off; they are then allowed to stiffen before a thickness equal to the thickness of metal is strickled on; the remaining space is then filled in to form the exhaust core. This

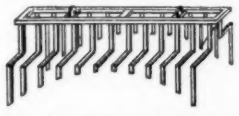

FIG. 48.—GRID FOR EXHAUST CORE.

method limits the number of men capable of working on the job, and therefore increases the time occupied in their preparation. Separate core-boxes are more suitable when speed is a consideration. The making of grids for these cores is quite an art, and various designs are formed to give the necessary strength to the cores, and yet be light and easily removed from the finished casting. One of the steam-way cores is shown in Fig. 45, and a suitable grid for it in Fig. 46. It will be observed that a number of pieces of wrought iron are bent to the shape of the core

FIG. 49.—GRID FOR LIGHTENING CORE.

from each opening in the chest face; these are then cast in a light form of grid. With this form the grid passes through the ribs, therefore part of it becomes incorporated with the casting. Sometimes wrought iron only is used, and tie-pieces are wired to them to make them rigid. The chest exhaust core is shown in Fig. 47, and the form of grid (Fig. 48) is somewhat similar to that for the steam-way core, but in this case the cast grid is made just a little smaller than the print and the shaped wrought-iron pieces are cast into it; tie-pieces are sometimes wired on, which pass through the ribs, to make the grid more rigid.

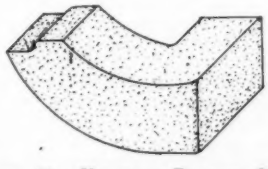

FIG. 50.—EXHAUST BRANCH CORE.

The other two cores required for the chest are the lightening cores, the grid for one of which is shown in Fig. 49. In this case the ordinary cast gaggers fulfil the requirements, providing their lengths vary as shown. In the making of all these cores it is necessary to give special attention to the venting: ashes should be introduced, and where the area is too small straw rope should be used. The only openings from which the air and gases can escape are through the chest face, therefore the ashes should be near to these outlets. The other large core, that for the exhaust branch, is illustrated in Fig. 50. In the sketch the full core is shown as coming flush with the centre core; sometimes the vertical section is made separately for convenience in making, but the fillet at the junction is frequently a difficulty. In making arrangements for venting this core some moulders cut through a junction with the chest exhaust core; this is risky. It will suffice if all the vent is brought off through the foot. The other cores require little consideration, the column foot core being swept up on a pin board, and, as this core is to be fastened in the cope, a suitable grid should be introduced.

When the cores have been prepared and dried, all the parts which come into contact with the molten metal need to be blacked. It is applied when the cores are warm and the moisture is quickly absorbed; there is therefore a tendency to apply the blacking thickly. Swabbing will remove the inequalities due to the blacking thickening, but it should be done with a reasonable amount of care, as some moulders remove practically all the blacking in this way, and the result is seen on the skin of the casting.

During the time of making the cores the mould will have been nearing completion, the pattern work having been withdrawn and the mould bradded where necessary, corners removed where

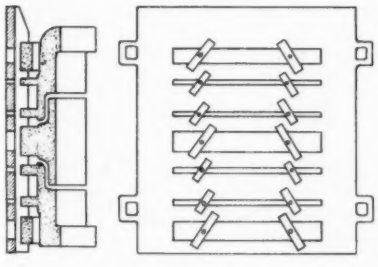

FIG. 51.—ATTACHING CHEST CORES TO DRAWBACK.

fillets are needed on the casting, and the whole swabbed and slicked over preparatory to being dried. When the mould is prepared in a case or pit, as illustrated, coke braziers or special driers may be lowered into the mould and the cope supported over the top on short standards, then sheet iron can be used about the sides to retain the heat. After drying, blacking is applied, as with the cores, and the mould is again dried.

When both mould and cores are thoroughly dried a commencement can be made to core up. The exhaust branch core is usually the first to be introduced, especially in this design, and, as there are no prints to locate it, chaplets must be depended upon. Many prefer to carry a drawback over the branch for convenience in setting the core; it can then be lowered straight into position and tested for accuracy by laths planed to the required metal thickness. Stud chaplets should be secured to the back of the mould, but at the top and bottom it will suffice if they fit neatly or are

FIG. 52.—TACKLE FOR CHEST CORES.

wedged. The number and position of chaplets require some discretion, as they are a source of weakness to the resulting casting. None should come into any part of the casting to be machined. The impression of the face of the chest is carried on the special plate, and all the chest cores are located and secured to it. The method is indicated in Fig. 51. The staples carried in the grids of the cores are cleared, and when the cores have been set in the drawback, bolts are hooked to them and secured to the back of the plate in the manner shown. This method determines their relative positions, and the introduction of a stud chaplet at convenient places gives that degree of rigidity desirable. Special lifting tackle is necessary in order to lower the drawback, with the cores attached, into the mould again, and for this purpose a couple of stout castings similar to that shown in Fig. 52 are suitable. The rectangular

hole is made large enough to pass over the snugs on the plate to which they are wedged, and the three holes at the top give a choice for slinging the drawback vertically, when it can be lowered into the mould and stayed from the side of the case. When it is in position sand should be rammed between it and the case, but it is necessary to clear the vents from each core. This is done by easing through the openings in the plate to the ashes in the cores and introducing more ashes from them to the backing sand, from which a contact is made with the top of the case. The cores which cut through the cylinder should be very carefully tested before any attempt is made to lower the centre core. It is better to have the port cores slightly clear of the main core; then there is less prospect of a breakage, as it is safer to have a thin fin of metal in the casting than to patch up delicate cores.

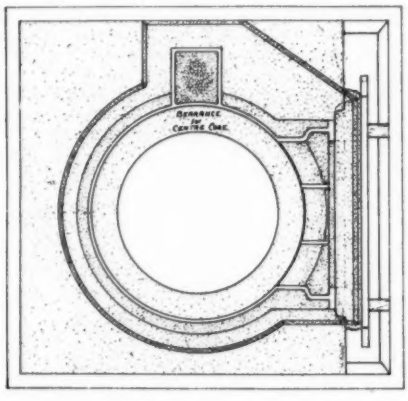

FIG. 53.—PLAN OF MOULD, WITH EXHAUST AND CHEST CORES SET.

A plan of the mould ready to receive the centre core is shown in Fig. 53. Careful handling of the crane is necessary in lowering the centre core, and it is better if it is kept slightly away from the chest cores until it is just about to enter the print, when pressure applied to the side of the core will suffice to locate it. After checking the height with the top of the mould, the stuffing-box core and the remaining part of the exhaust-branch core can be located. In both cases the use of top prints in the cope is frequently dispensed with, as they are a probable cause of trouble when closing. The latter should be secured to the other part of the branch core, and before the stuffing-box core is placed sand can be lightly rammed inside the centre core. The other cores are secured in their

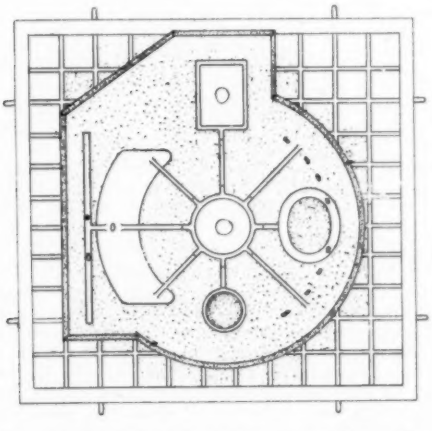

FIG. 54.—COVER CLEANED OFF AND CORES SET.

relative positions in the cope, an illustration of which is shown in Fig. 54. When all the cores have been set and heights have been tried to prevent crushing, the cope can be lowered; it is necessary, however, to make sure that the metal will not enter the vents between the cope and those cores which come in contact with it; a trial is therefore an advantage. Well-kneaded clay is used in convenient places to determine the thickness between the cope and the main core, and a little is applied to the top of the cores which come flush with the cope; then the cope is lowered into its relative position. On its removal, the thickness of clay determines the thickness of metal and gives a guide for the size of chaplets to be used. When these have been set and a thin clay band placed on the cores to surround the vents, the cope can be finally lowered into position. The moist clay used should be covered with oil to prevent any agitation of the metal from the moisture.

The general arrangement for casting is shown in Fig. 55. The runner is prepared in loam on a special plate having gaggers cast about it. This runner should be dried and blacked, but the riser basins may be formed with floor sand, and they need not be dried. These are set in their respective positions, and loam or sand used about them to prevent any escape of metal. The cope

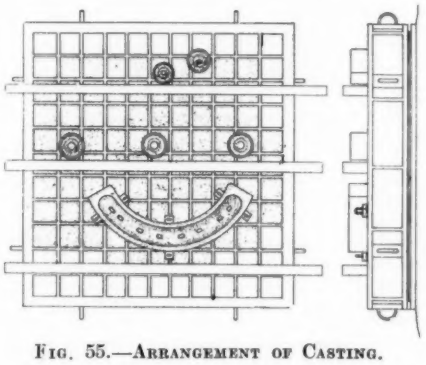

FIG. 55.—ARRANGEMENT OF CASTING.

is then weighted or clamped down to resist the lift. When the joint flanges of the cope-box and case are cast with a number of equidistant holes, as shown in Fig. 56, bolts may be used with advantage, but, failing these, clamps can be used between the case flange and the top of the cope-box, with the addition of weights on the top, or weights alone may be used. The metal of which cylinders of this description should be composed needs to be tough, of good wearing quality, and having a close grain. Many founders now make

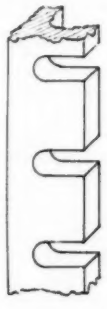

FIG. 56.—TOP FLANGE OF CORE.

a practice of preparing special pig, which they use to a considerable extent for work of this character. There is no definite formula which can be given as the cupola charge, as the fuel and running conditions play an important part in the character and quality of the metal obtained. To obtain a dense iron it is profitable to keep the manganese contents comparatively high, with silicon under 2 per cent.

MOULDING SAND PRODUCTION IN THE U.S.A.—The production of moulding sand in the United States in 1920, according to the U.S. Geological Survey, was 4,890,000 net tons as compared with 3,774,612 tons in 1919 and 4,910,178 tons in 1918. The total quantity of sand and gravel produced last year was nearly 78,000,000 tons or about 7,000,000 tons more than in 1919.

Institution of British Foundrymen.

LONDON BRANCH.

Discussion on Mr. Heggie's Paper on Pattern Plates.*

MR. A. R. BARTLETT, who opened the discussion, said he had hoped Mr. Heggie would have dealt with something which he himself had not heard of or seen, but he had not been fortunate enough to hear that. The author had spoken of reversible plates, but there was one point which he had not made quite clear, and that was the weakness of a reversible plate when making castings which must carry a clean surface. The reversible plate was certainly useful from the point of view of production, but if they were making castings which had to have a clean surface they were running the risk of half of them being wasters. It was very often that the top side of a casting was dirty, and they could not make them all face downwards on a reversible plate, so that for castings for many purposes the reversible plate was not practical. The lecturer had reminded him of war-time when he had seen the handle on the machine, because that was a quick method of making shell punches, and certainly one of the most economical methods of drawing a pattern and getting a perfectly finished mould. The author had not mentioned, however, that when he turned the handle on the machine the mould was finished also.

With regard to box pins, the author had invited discussion on this subject. He had said that two box pins were all that were really essential. He himself agreed that in the greatest number of cases with small work two box pins were all that were essential, but when working with, say, a 4 ft. 6 in. square box on a moulding machine it was a mistake to use only two on a direct centre line, because the corner was so far from the centre line, and the least movement made a very big discrepancy in the casting. He contended, therefore, that three or four were really essential on the large type of moulding machine. He would like to ask with regard to box pins on, say, the 16-in. boxes the author used on the Adaptable machine, how much clearance he gave to his pins or pin holes. Did the author have pin holes so many hundreds or thousandths of an inch larger than the pin, or was the clearance smaller; did he keep two pin holes of the standard size; did he have pins in both the top and the bottom, or did he have loose pins? His reason for asking was that if the author had two pins in the bottom and had one reversible plate, and if the man responsible was not paying very much attention, he did not trouble which way round the top went. If there were one pin in the top and one in the bottom he could not put the box on the wrong way round. When they used steel pins, fixed in the bottom or the top, when the mould was cast with the pins in position the steam given off from the mould came into contact with the pins and rusted them away, so that the boxes very soon became loose on the pins. Did the author find it better to work with loose pins for closing down the work, or what methods did he employ in connection with pins and pin holes?

MR. J. ELLIS (Past President of the Institution) said that following the remarks of Mr. Bartlett with regard to not being able to get the tops clean, he had had a tip given to him by a very learned gentleman. As soon as the mould was cast, turn the top to the bottom, and there were two bottoms. They had heard, perhaps, rather too much of the "Adaptable moulding machine," and he would like to have seen plates showing other machines. It was a question whether the plate attached to a machine really was preferable to the pure plate moulding. He would like Mr. Heggie's opinion as to whether the patterns cast on a plate were as economical from a pattern-preparing point of view as the half patterns screwed on to a machined plate. He knew that in some cases where the joint was irregular it could not easily be done, except by coring out, but where patterns could be put on a plate with a straight joint he thought the most economical way would be to screw them on to a machined plate.

MR. V. C. FAULKNER referred to an inquiry he had received asking for a substitute for plaster for making cheap offsides from wooden patterns, as this material cracks when used with jar-ramming machines. He had written back and suggested that perhaps a special cement would be found suitable, but his correspondent replied that he feared that cement would not resist the vibration. Could Mr. Heggie suggest a material?

MR. WESLEY LAMBERT said that, with reference to a material which would stand up to the jolt-rammer, it had just occurred to him that gramophone-record wax was a very strong material, and he did not know whether it had ever been tried.

MR. B. HIRD said he had been using Adaptable machines for making air-cooled cylinders. For the first pattern he went to the trouble of making a special stripping-plate. On a subsequent occasion, however, there was not time to make a stripping-plate, so he decided to try it without. It was a well-made split-pattern turned out of solid brass, with ribs moderately close and deep. He fixed one-half on each side of a machined plate. To his surprise the first mould came off the machine perfectly. The only sprigs used were two to each rib on each half placed close to the plate. A large number of moulds were made by this method successfully. Another pattern, rather more intricate, having the cylinder and head combined, was tried, using the same method, again with complete success. Three Adaptable machines are working continuously on these patterns with scarcely any bad draws. In spite of the fact that no sprigs are now used, he mentioned this because he thought this method was worth a trial before going to the expense of rigging up stripping-plates, which were very expensive. With regard to making pattern plates, Mr. Heggie mentioned the method of casting the plate over the metal patterns, then fixing these patterns to the plate, thus saving time filing up. That was quite good practice for some castings, but one must take into consideration, and make allowance for, the contraction of the plate when cast, otherwise a bad match would result. As to pattern plates generally, each one required a special study of the method to use, quite a lot of time and money could be spent on a pattern plate, which, in the end, might be scrapped through some small oversight.

Referring to Mr. Faulkner's inquiry for a substitute for plaster, he remarked that he, too, was looking for such a material. He had tried pitch, but when he had put it on the jolt-rammer it cracked worse than plaster. Something was necessary to get rid of the vibration. He had also unsuccessfully tried mixing rubber with pitch.

Referring to boxes and box pins, the speaker remarked that when supposedly interchangeable boxes came from the machine shop they often left very much to be desired. Boxes were planed on the edges, but instead of working to the planed face the drillers in the machine shops worked from rough bottom edges. He had a number of planed plates which were being used for another job, and these were put on the bottom half moulds of the box-parts instead of a top-part, and cast the boxes against them, thus they obtained a dead-level chilled-face. A drilling jig-plate was put on two parallel iron-strips, which were a little deeper than the box, and rested on the table. The chilled level edges of the box-part were bolted tight against the jig-plate, thus ensuring a perfectly upright hole. As to the use of pins, there were various methods which could be adopted. If they were using only two pins, one could be of slightly larger diameter than the other. This would prevent the boxes being put on the wrong way round. It was easier to drill one hole, say, $\frac{3}{4}$ in. and the other $\frac{7}{8}$ in. than to work with one round and one square hole, and just as advantageous. He was an advocate of loose pins, but it was a matter of judgment as to whether they should be used or not. He had found that for some boxes for cylinders they were using loose pins and bolting them with a couple of bolts, and the time taken in bolting the box together after the loose pins had been withdrawn was a fairly big item. It paid them better to get some cotter pins for that particular job. One could not be too dogmatic on these points, and there were always many things

* For paper see page 515, *et seq.*

to be taken into consideration when suggesting methods of production to other foundrymen.

MR. H. O. SLATER said plate-pattern making could not be altogether explained; in making plate patterns there were so many details involved, and it was impossible to explain them all, although the author had dealt with many of them. As to his experience with pins, in order to prevent the box being put on the wrong way he preferred a square and a round hole. He certainly preferred both pins on the drag part instead of one at the top and one at the bottom. There was one item not mentioned by the lecturer in making plates, which, he thought, was one of the greatest pitfalls and that was the contraction on the patterns. If a customer sent in a pattern he might have to produce castings quicker than by the ordinary method, and the plate-pattern would have to be made from the pattern sent in by the customer. Very often it would be found, unless double contraction was allowed for such castings as exhaust pipes from automobiles, that the flanges came out very irregularly compared with the pattern sent in. As regards the wax mentioned by Mr. Lambert, he had had experience of gramophone wax, and it was absolutely unsuitable for patterns.

THE BRANCH-PRESIDENT (Major Gordon) said he had recently been connected with a law case dealing with plate moulding. The articles concerned should have been round, but when cast a lot of them were found to be elliptical, and he took it that was the fault of the plate, or the pin in the hole. As to the assembling of patterns on plates, the average pattern-maker tried to do that with the aid of a scriber or marking knife, but his experience was that that practice would lead them astray. The only reliable method was to make dowels going right through the plate and joining on the other side. Most pattern-makers would agree with him that when they sent a plate over to the foundry to see whether it was all right, there was always a gasp of relief if it happened to be correct at first.

MR. F. E. PEARCE asked the author whether he made his all-cast plates only $\frac{3}{8}$ in. thick when he happened to be working with a white metal, or whether he made them thicker. It appeared to him that $\frac{3}{8}$ in. was rather too thin, and he had seen plates of this thickness buckle.

MR. A. WILLIS said with regard to the fitting of the bolts on the plate with sufficient accuracy for small non-ferrous work, although he had them drilled right through, with dowel pins to hold the pattern on either side, the patterns were still very much out—sometimes as much as 1-16th in. on a small pattern of $\frac{1}{2}$-in. or $\frac{3}{4}$-in. diameter in parts. He thought the trouble was due to the drilling of the plate on the drilling machine; the plates were not true. In another case it had been found that the plates were put on a lathe to be turned instead of being machined on a bed of a planing machine, and there was a spring on the plate; consequently, a bad result was thereby obtained. He pointed out that when making plates for accurate non-ferrous work there was only a small or no machining allowance. Some brass or gun-metal castings had to go from the foundry to the finisher to be bored and screwed, but others went direct to the polishers without having any work put on them, thus giving no machining allowance. In such cases he should say more than two pins were required, because they soon deteriorated. The same thing applied to the all-cast plates. He could not see that an all-cast plate could be made with sufficient accuracy to turn out castings where there was a minimum machining allowance. It was all right for the iron trade, where there was anything up to $\frac{1}{4}$ in. machining allowance, but for non-ferrous castings it became a much more difficult problem to turn out a true casting, and engineers would have to appreciate the fact. Personally, he would prefer making the cast plate. He thought there was a better chance of getting a true plate if they were cast as described by Mr. Heggie, with machined layers round the sides of the mould to lift up the mould a certain distance, providing the machine was true, rather than by trusting to the ordinary engineer in a factory to do the machine part. That was the point of view of the non-ferrous worker, who had not large machining allowances.

The Author's Reply.

MR. HEGGIE, replying to the discussion, said that in regard to not having told Mr. Bartlett anything he did not known, he (Mr. Heggie) was very well satisfied that that was Mr. Bartlett's only complaint, because, as most of them were aware, Mr. Bartlett was himself an expert on pattern-plates.

As regards pins, he would not care to state that any particular method was best—there was not much in it—and existing conditions often help in coming to a decision. Boxes with fixed pins had certainly to be more carefully stored, as a bent or rusty pin made the box useless until rectified. The clearance he allowed in the holes was 0.006 in. Referring to reversible plates, he agreed with Mr. Bartlett, and, as mentioned in his Paper, the fact of certain parts of some castings being in the drag and the same parts of others being in the top, ruled out in many cases the reversible plate.

Stove grate work on floor plates compared with machines had been mentioned by Mr. Ellis. Many of the plates of the sizes quoted had been worked on the floor, and, as he had already stated, he knew of no machine which could compete successfully with them at the present time.

He had been asked whether it was more economical to have all-cast plates or to have the patterns screwed on. He could not decide that, as there were so many and various kinds of plates. It was impossible to give a comparative estimate so far as the price went, but he had no hesitation in saying that when it could be done it made the best job to have plates planed and fix the patterns on, though it cost a little more. He agreed with the President that it was very difficult to get an all-cast plate of a complicated nature to give correct joints first time.

He did not agree with Mr. Willis that cast iron people were allowed a machining allowance of from 1-16 in. to $\frac{1}{4}$ in., and if the joints were 1-64 in. out from any class of plate he would consider it wrong.

As to Mr. Faulkner's questions, he had not much experience with plaster work on a jolt machine, and he was not prepared to recommend any mixtures as suitable.

As to plates $\frac{3}{8}$ ins. thick, when speaking of this thickness he was referring to the ordinary all-cast floor plates. The actual thickness of the plates for sizes quoted was 11-32 in. Mr. Heggie, in expressing his thanks, referred to the remark made that there had been rather too much of the Adaptable machine, but he was in no way connected with the Adaptable people except that he made plates for their machines, as well as for others, and they had kindly lent him several slides, and he could not very well leave out the name.

Publications Received.

MESSRS. METROPOLITAN VICKERS, LTD., Trafford Park, Manchester. "Buffing Motors" and "Electric Arc Welding."

MESSRS. CONSETT IRON CO., LTD., Consett, Co. Durham. "Table of Extras, Applicable to Steel Plates and Sectional Material."

MESSRS. THE BRITISH ALUMINIUM CO., LTD., 109, Queen Victoria Street, London, E.C. "Aluminium—Facts and Figures." Price 5s.

MESSRS. SALTERNS, LTD., Parkstone, Dorset. "The Development of Water Power."

THE INDUSTRIAL WELFARE SOCIETY. "The Journal of Industrial Welfare for May." Price 9d.

THE INDUSTRIAL LEAGUE AND COUNCIL. "Journal for May." Price 6d.

ANOTHER DIRECT PROCESS.—The perennial announcement of a solution to the problem of economically producing steel direct from iron ore without the expensive middle process of making pig-iron has been made by James W. Moffat, of Toronto. He states that by means of an electric furnace he is able to attain the results claimed by a French inventor, M. Basset, and that the process is much cheaper than is involved by the use of the open-hearth method.

Trade Talk.

KELSALL BROTHERS, LIMITED, have removed to Delamere Place, Chester Square, Ashton-under-Lyne.

MESSRS. W. H. DORMAN & COMPANY, Foregate Street, Stafford, have closed down their works temporarily.

THE LONDON SHAFTING & PULLEY COMPANY have removed to Northdown Works, Northdown Road, King's Cross, N.1.

MESSRS. JOHN & CHARLES MURRAY, iron and steel merchants, colliery furnishers, etc., have removed to 256, West George Street, Glasgow.

THE Institution of Electrical Engineers, at a special general meeting, decided to apply to the Privy Council for a Royal Charter of Incorporation.

A MAJORITY of the members of the Boilermakers' Society have voted in favour of amalgamation with the Shipwrights' and Blacksmiths' Societies.

THE Manchester offices of the Frodingham Iron & Steel Company, Limited, have been removed to Temple Chambers, 33, Brazennose Street.

MR. C. A. EMBLETON, pig-iron, steel and metal merchant, has removed from 82, Victoria Street, Westminster, S.W.1, to Moorgate Hall, Finsbury Pavement, E.C.2.

THE head office of Messrs. H. Perks & Company is now The Foundry, Stanley Road, South Harrow, instead of 90, Seymour Place, W.1. The company are still retaining their London office.

IT is officially announced that Sir Edward Mackay Edgar, of Sperling & Company, has purchased the entire ordinary share capital of the Blythswood Shipbuilding Company, Limited, situated on the Clyde.

MESSRS. CLAYTON & SHUTTLEWORTH, LIMITED, have issued a pamphlet stating the costs of production must be reduced to stimulate new orders, and that these costs cannot be brought down without reduction in wages.

OWING to the shortage of fuel and the poor outlook in the iron ore industry, the Cleator Iron Ore Company have decided to cease pumping operations, and to close the Margaret Mine. The machinery has been brought to the surface.

THE Australian House of Representatives is at present engaged in a prolonged discussion on a proposal, moved by the Labour party, to increase the present duties on pig-iron 20s. a ton British preference, 30s. intermediate tariff, and 40s. general tariff—to 30s., 45s., and 60s. respectively.

AT the annual meeting of the British Science Guild, held at the Goldsmiths' Hall on the 8th inst., Sir Richard A. S. Redmayne (chairman of the Imperial Mineral Resources Bureau) delivered an address on "The Importance of Research in Promoting the Development of the Mineral Industries."

THE tender of the Metropolitan Vickers Company, of Manchester, of £294,117 has been accepted for the complete manufacture of the generating plant at the Victorian Government's Morwell enterprise for supplying the greater part of the State with electricity. American and Swiss companies also tendered.

THERE were launched from the Wearside shipyards during the month of May four vessels, with an aggregate tonnage of 22,645. This makes a total output of thirteen vessels for the present year, with a tonnage of 61,427, which is less than half the output for the corresponding period last year, when thirty vessels, aggregating 134,018 tons, were launched.

THE shipbuilding and engineering business of Messrs. J. Burrows & Company, Oban, has been taken over by Messrs. Wilson & Vass, Argyll Engineering Works, Oban, and the slipway at Portman-cuilc will be worked in future in conjunction with the latter firm's engineering establishment under the designation of Wilson, Burrows & Company.

THE 21st house dinner and general meeting of the Norwegian Chamber of Commerce in London was held recently at the Connaught Rooms. Mr. J. Jorgensen, president, and a founder of the Chamber, who was in the chair, said that having regard to the labour trouble, high taxation, and the breakdown of foreign markets, the results obtained by British traders during the year had been admirable.

THE quarterly report issued by the Central Ironmoulders' Association shows that the membership for the March quarter increased by 32, the total being 6,944, as compared with 6,912. On the financial transactions over the period there has been a loss of £953, the total funds in hand being £17,936, as against £18,890 at the end of last year. The income for the quarter was £2,251, and the expenditure £3,204.

THE result of the ballot for the election of new officers and members of the Council of the Institution of Electrical Engineers for 1921-22 is as follows:—President, Mr. J. S. Highfield; vice-presidents, Professor E. W. Marchant, D.Sc., and Mr. C. C. Paterson; hon. treasurer, Sir James Devonshire; ordinary members of Council, Mr. S. Evershed, Lieutenant Colonel F. A. Cortez Leigh, Sir Andrew M. Ogilvie, Mr. A. Page, Mr. T. Roles, and Mr. A. W. Tait, C.B.E.

THE SECRETARY FOR MINES, under the provisions of the Coal Emergency Directions, has decided and directs as follows:—"For the purposes of Part IV. of the Coal (Emergency) Directions, 1921, any metallurgical coke at a coal mine is included in available stocks, and may be distributed by the District Coal and Coke Supplies Committee for the district in which such coal mine is situate under the provisions of Articles 1, 18 and 19 of the said Directions."

WE have been informed by the secretary that the Proceedings of the Institution of British Foundrymen is in the hands of the printers, and will shortly be issued to members and associate members. Non-members of the Institution desiring to have the Proceedings can obtain copies, price 6s. net, from the secretary, Mr. W. G. Hollinworth, Bessemer House, Adelphi, Strand, London, W.C.2. As the issue is limited in number, applications will be dealt with in order of priority.

MR. A. PEECH, chairman of the United Steel Companies, Limited, of Sheffield, expresses the view that the future of the British steel industry is entirely dependent on the price which that industry has to pay for its coal, and, therefore, its coke. In order to manufacture pig-iron at £6 per ton coke must be delivered to the blast furnace at about 30s. per ton, and in order to make coke at this price the industry cannot afford to pay more than about 15s. per ton for its coal.

British Cast-Iron Research Association.

Industrial Research announces that a licence, under Section 20 of the Companies' (Consolidation) Act, 1908, has been issued by the Board of Trade to the British Cast-Iron Research Association, which has been approved by the Department as complying with the conditions laid down in the Government Scheme for the encouragement of industrial research.

The Association was registered on June 1 as a company limited by guarantee. The objects are: To conduct research and other scientific and experimental work in connection with the cast-iron trades and industries and any trade or industry using grey and malleable iron castings or in producing substances, accessories, articles, machinery or appliances connected with the said trades or industries. The management is vested in a Council, the first members of which are:—

Rt. Hon. Lord Weir of Eastwood, P.C., Holm Foundry, Cathcart, Glasgow (President); Vice-Admiral Sir George G. Goodwin, "Merlewood," Albion Road, Sutton, Surrey; Sir James McKechnie, K.B.E. (director of Vickers, Ltd.), Barrow-in-Furness; D. Vickers (chairman of Vickers, Ltd.), Vickers House, Broadway, Westminster; A. Laing, Wallsend Slipway, Wallsend-on-Tyne, marine engineer; P. W. Petter, Westland Engine Works, Yeovil, mechanical engineer; J. E. Stead (Pattinson and Stead), 11, Queen Terrace, Middlesbrough-on-Tees, analytical chemist; M. Deacon, Sheepbridge Works, Chesterfield, director, Vice-President; H. B. Weeks, 2, Infield Park, Barrow-in-Furness, metallurgical chemist; F. J. Cook, 139, Poplar Avenue, Edgbaston, Birmingham, director; M. Riddell, "Crugryn," Aytoun Road, Pollokshields, managing director; E. Adamson, "Lilburn," Dore, near Sheffield, metallurgical engineer; J. Arnott, 14, Percy Street, Ibrox, Glasgow, metallurgist; J. Cameron, "Norwood," Lenzie, Glasgow, managing director; J. E. Fletcher, "Keston," St. James Road, Dudley, consulting mechanical engineer; W. J. Foster, Moorlands, Kenilworth, ironmaster; J. E. Lester, 27, Augustus Road, Edgbaston, Birmingham, metallurgist and managing director; J. T. Goodwin, "The Red House," Old Whittington, Chesterfield, foundry manager; T. F. Hardyman, Bayford Lodge, Summerlands, Yeovil, foundry manager; F. C. A. H. Lantsberry, Royal Victoria Station Hotel, Sheffield, steel works manager; J. P. Mackie, Albion Foundry, Belfast, manager; A. F. Mason, Steel Works, Barrow-in-Furness, manager; W. E. Parker, 1, Murray Road, Rugby, chief chemist; C. Retallack, Clifton, Anchorage Road, Sutton Coldfield, ironfounder, managing director; O. Stubbs, Mill Street Works, Ancoats, Manchester, managing director; F. J. Taylor, Oakwood, Briton Ferry, South Wales, mechanical engineer; R. O. Patterson, Thorneyholme, Wylam-on-Tyne, foundry manager; H. J. Young, North Eastern Marine Engineering Co., Ltd., Wallsend-on-Tyne, chief chemist. Secretary, T. Vickers. Solicitors, Rowlands & Co., 41, Temple Row, Birmingham. Registered office: Central House, New Street, Birmingham.

XUM

Gazette.

The Stoneycroft Electrical Works, Limited, are being wound up. Mr. E. Chetter, 26, North John Street, Liverpool, has been appointed liquidator.

Messrs. H. Stockwell and A. B. Williamson, engineers and merchants, 52, Corporation Street, Manchester, trading under the style of H. Stockwell & Company, have dissolved partnership.

The partnership heretofore subsisting between Messrs. J. Boyle and C. B. Redrup, engineers, 10, St. Stephen's Road, Burmantofts, Leeds, under the style of Boyle and Redrup, has been dissolved.

Messrs. W. S. Bass and R. A. Jones, electrical engineers, 402, Essex Road, Islington, trading under the style of Bass & Company, have dissolved partnership. R. A. Jones will continue the business.

A winding-up order has been made against the Crawford Foundry Company, Limited, 4 and 5, Crawford Passage, Ray Street, Farringdon Road, London, E.C. The creditors and contributories met on June 15.

The public examination of Mr. S. F. Rogers, ironfounder, Cemetery Road, Rood End, Oldbury, Worcs., has been held at the Dudley Bankruptcy Court. The statement of affairs showed the gross liabilities to be £1,993, the deficiency £1,693, and the causes of failure, as alleged by the debtor, were "depreciation of plant and stock, loss on business owing to faulty castings, and insufficient capital." The examination was adjourned.

The names of the undermentioned companies have been struck off the Register of Joint Stock Companies, and such companies are dissolved:—International Drilling Company, Limited; Isaacson Radial Engine Company, Limited; Lancashire Brass Founders, Limited; Marshall's Valve Gear Company, Limited; Nottingham Malleable and Steel Castings Company, Limited; Railways and General Construction and Maintenance Company, Limited; Richardson's Turbine Company, Limited; Schmidt Steam Power (Parent) Company, Limited; Statax Engine Company, Limited; and Wren Patent Safety Coupler, Limited.

Deaths.

Mr J. W Willis, Thornaby-on-Tees, whose recent death is reported, was for over 30 years connected with the firm of Head, Wrightson & Company, engineers, Teesdale Ironworks.

The death has taken place at his residence, Crontelle, Stocksfield, of Mr. Edwin De Russett, naval architect, who, prior to his retirement some years ago, was a prominent member of the designing staff of Messrs. Swan, Hunter & Wigham Richardson, Wallsend.

Personal.

Professor R. F. Ruttan, McGill University, Montreal, has been nominated, says the "Chemical Age," as president for next year of the Society of Chemical Industry, in succession to Sir William Pope, who vacates the office in August.

Mr. Arthur Stowey Bailey, O.B.E., Managing Director of the Nottingham Railway Carriage and Wagon Works of Messrs. Cammell Laird & Company, Limited, has been appointed a Director of the Company with a seat on the Board.

Brigadier-General C. P. Martel, C.B., Chief Superintendent of Ordnance Factories, Woolwich, is retiring shortly. He will be succeeded by a civilian. Among the posts he had previously held were those of Superintendent, Royal Gun and Carriage Factory, member of the Ordnance Board, Professor of Artillery, Ordnance College, and Principal Experimental Officer.

In the King's Bench Division, Mr. Justice Bailhache had before him an action brought by David Cameron & Company, Fenchurch Street, London, against H. Alexander Flinn, Victoria Street, London, claiming damages for alleged breach of contract in connection with the supply of steel plates. The defendant was not represented. Counsel asked for judgment for £7,169 18s. 4d. His Lordship entered judgment for the plaintiffs for the amount claimed with costs.

The British Association has struck a new note in issuing the preliminary programme of its 89th annual meeting, at Edinburgh, from September 7 to 14. Hitherto it has not been the practice to announce the subjects of the principal addresses and discussions until shortly before the meeting.

Company News.

Aimers, M'Lean & Company, Limited. — Capital £25,000 in 12,500 preference and 12,500 ordinary shares, both of £1 each, to acquire and carry on the business of engineers, ironfounders, etc. Registered office: Waverley Ironworks, Galashiels.

Butler & Son (B. and S. Valves), Limited.—Capital £20,000 in £1 shares, to take over the business of founders and finishers, etc., carried on by B. Butler and W. Butler as Butler & Son. Registered office: Borough Brass & Iron Works, Furnace Street, Dukinfield, Chester.

Chili Iron Syndicate, Limited. — Capital £100,000. Registered office: Warnford Court, Throgmorton Street, E.C.2.

Cooke & Glover (Engineers), Limited.—Capital £5,000 in £1 shares. Registered office: 98, St. Peter's Street, Radford, Nottingham.

Coventry Chain Company, Limited.—Interim dividends, 6 per cent. per annum on ordinary and preference.

Kingdon & Company, Limited.—Capital £2,000 in £1 shares (1,000 9 per cent. non-cumulative preference), to carry on the business of ironfounders, etc. F. B. Kingdon is permanent director.

New Welding Company, Limited.—Capital £25,000 in £1 shares (5,000 preference). Registered office: 26, Rosebery Avenue, E.C.

Poldi Steel Company (England), Limited. — Capital £20,000. Directors: E. Penn (managing director), A. E. Hukins and J. C. Yeomans. Registered office: 75, Victoria Street, Westminster, S.W.1.

Sheffield Steel Products, Limited. — The directors have decided to pay first dividend of 10 p.c. on cumulative preference for half-year ended May 31, 1921, on July 1, and thereafter half-yearly warrant will be dated January 1 and July 1 in each year.

Zinc Corporation, Limited.—Profit, £31,910: appropriations unexpended and written back, £19,952; brought forward, £42,812; development, etc., £27,000; income and corporation tax, £23,265: depreciation of stores, £10,000; preferential dividend for first half-year, £24,569: ditto, second half year postponed; carried forward, £9,840.

Sanders, Rehders & Company, Limited, 108, Fenchurch Street, E.C.3, are transferring to the Sarco Engineering & Trading Company, Limited, King's House, 36 and 38, Kingsway, W.C.2, the business, in London and Manchester, of their two engineering departments (the "Sarco" and the "Machinery") for the purpose of greater development. Messrs. Sanders, Rehders & Company retain, of course, a substantial interest in the business. The "Sarco" Company's warerooms and workshops are at 124, Long Acre, W.C.2.

The council of the Federation of British Industries, in a letter to the Postmaster General on the subject of the increased postal rates, point out that these increases are being imposed at a time when every other business in the country is being forced to reduce its costs and its prices in order to meet the economic position, and the Federation finds its difficult to understand why a business, which only differs from others in that it is conducted by the Government and enjoys the advantages of monopoly should be unable to follow their example.

An engineers' club for London, to which previous reference has been made in the Journal, has been established at a largely attended meeting at the Hotel Cecil, held under the chairmanship of Mr. C. H. Wordingham past president of the Institution of Electrical Engineers. The temporary secretary, Mr. Edmund Hill, stated that 1,665 applications for membership had been received. They hoped to acquire the premises of the Road Club, in Coventry Street, and open it on July 1. A general committee was appointed, with Mr. Edward Manville M.P., as president, and Mr. E. L. Hill, honorary secretary, to whom all communications should be addressed at 39, St. James's Street, S.W.

The Secretary of the Ministry of Labour makes the following announcement:—At a recent meeting of the Hollowware Trade Board (Great Britain), it was resolved to issue a notice of proposal to vary the general minimum time rates and overtime rates for male and female workers in the trade, and to fix a piece-work basis time-rate for female piece-workers of 18 years of age or over. The variations proposed provide for reductions in the general minimum time rates at present effective, the principal of which are:—Male workers other than learners from 58s. 6d. per week of 47 hours to 1s. 2½d. per hour. Female workers other than learners from 34s. 3d. per week of 47 hours to 8d. per hour. Reductions are also proposed in the general minimum time rates for male and female learners. It is proposed to fix a piece-work basis time rate for female workers of 18 years of age or over of 9d per hour. Corresponding reductions are proposed in all the overtime rates.

Telegrams : "THROWER, GLASGOW." Telephone : 5909 CENTRAL.

ALBERT SMITH & Co FOUNDRY ENGINEERS. TOOLS & EQUIPMENT

Head Office: **60, ST. ENOCH SQUARE, GLASGOW.**

SAND BLAST EQUIPMENT. For Any Service.

MOULDING MACHINES. Electric, Air & Hand Power.

FORCED DRAUGHT. Core Stove, Furnaces.

PORTABLE CORE OVENS.

CORE MACHINES. Core Compound. Core Oil. Glutrin. Parting Powder. Perforated Chaplets, Etc.

BRASS RECOVERY MACHINES. New Process.

...TRADE... SIROCCO ...MARK...

CENTRIFUGAL FANS

For Supplying Blast to

Cupolas and Forge Fires.

Made in a large variety of sizes and suitable for pressures up to 30-in. W.G. The Fans have cast iron casings and the belt driven type are fitted with Ball Bearings.

Send for particulars to :—

DAVIDSON & CO., LTD.,

Sirocco Engineering Works, Belfast.

IRON AND STEEL MARKETS.

Pig-iron.

The more hopeful prospect of an early cessation of the miners' dispute has influenced to some extent a corresponding feeling in pig-iron markets, but with production at a complete standstill has had little stimulating effect upon business in general. The majority of manufacturing industries are, of course, practically out of action from lack of fuel, but some of the foundries are still working, and those which are idle will certainly get started much more quickly than the blast furnaces, so that the probability of a shortage of iron increases. Stocks of foundry iron at makers' works are practically exhausted, and supplies all round are likely to be short. In consequence of this, makers are asking premiums, and for Derbyshire brands Midland sellers quote as much as £1 a ton higher than a month ago, the quotation for No. 3 being in the neighbourhood of £8 5s. to £8 10s. Foreign competition is a primary factor. Belgian pig-iron of No. 3 quality is obtainable at £6 10s. delivered in the Midlands, and in face of this there is little chance of an upward movement at home receiving encoufagement. In the West of Scotland, as the pig-iron smelters have closed down, any demand that there is, is being supplied from stocks, and foundry grades are now scarce. It is expected that local makers will quote lower prices when the industrial upheaval is at an end, but much will depend upon the costs of production, in which coal is the chief factor at present. At Middlesbrough the market remains lifeless, the export demand for Cleveland iron being negligible, but makers continue to demand a 5s. premium for foundry qualities for overseas shipment, though they would be glad to sell forge iron at the home quotation of 117s. 6d. per ton. Quotations meanwhile are unchanged, as follows:—No. 1, 135s.; No. 3 G.M.B., 130s.; No. 4 foundry, 129s.; No. 4 forge and mottled, 117s. 6d.; white, 115s.

East Coast hematite makers are using the period of inactivity to effect furnace repairs, and as they have still plenty of iron on hand may not be in a hurry to light up again. Even the 10s. discount fails to tempt foreign buyers in any number, and it is stated that 150s. might be shaded for mixed numbers for export, although the home minimum is still firmly maintained at 160s per ton.

Scrap.

In all the chief centres of consumption, demand for scrap material in any form, ferrous or non-ferrous, is practically non-existent, the few foundries now operating having in most instances fully covered requirements previous to the stoppage, and with depleted stocks of fuel, are declining further commitments until confidence is restored. In Lancashire, however, one of the most important markets for this class of metal, foundrymen, taking long views of the situation, are occasionally taking up small parcels of scrap for stock in anticipation of a temporary shortage of pig-iron when the present strike trouble is ended, but transactions are on a minor scale, and afford no real test of the most important markets of this class of metal. Holders of best textile machinery, cast scrap, are consequently inclined to stiffen values for this quality of metal, for which up to £7 per ton is asked. The prices for all the other kinds of iron and steel scrap are purely nominal.

Finished Iron.

Pending the now anticipated early settlement of the fuel difficulty, business in all descriptions of finished iron is obviously impossible, and consequently remains in its usual stagnant condition. Inquiries for material are, however, coming forward occasionally, and although orders are on a small scale, it is hoped there will be sufficient accumulation in hand to provide for a restart when work is resumed. In South Staffordshire the chief subject of discussion is the question of prices in the future. Consumers incline to the opinion that crown and marked bars will have to be reduced to appreciably less values than the figures at which they now nominally stand. With regard to the latter it seems to be accepted that the end of the strike will prompt an announcement of a considerably lower basis, but makers of crown bars retort that unless they are able to obtain substantial relief in the prices of fuel and pigs less than £19 will be ruinous. With costs at present levels, it is stated that this price leaves no profit. In the engineering trade orders have fallen to vanishing point. Here, again, when the mines are at work once more, the main difficulty will be to recover the lost foreign trade. Markets no longer wait for us. They will have to be taken by storm against strongly entrenched competitors.

Tinplates.

While distinctly more hopeful in outlook, conditions in the Welsh tinplate trade do not by any means inspire expectations of an early revival of activity at works, and business in the market is still confined within the narrowest limits. Demand, both on home and overseas account, continues restricted, the slump in tinned provisions, of which enormous stocks were left over as a legacy of the war, doubtless explaining the slackness of inquiries in that direction. Meantime the market is quiet, but there is some demand for prime stock plates, for which sellers are holding out for 25s. 6d. to 26s. basis f.o.b. Stock plates are being absorbed, and with the works idle there is likely to be a general scarcity, particularly of light weights. Full weight, 28 by 20, are almost out of stock. Although there are inquiries from the Continent, no real business is materialising, as the rates of exchange are still an adverse factor, but for the Far East primes and wasters 20 by 14's, have been bought.

Steel.

Notwithstanding the lightening of the industrial situation by the decision of the miners' leaders to take a ballot of the members with a view to an early resumption of work at the collieries, the effect upon the steel trade so far has been practically negligible from a market standpoint, with business continuing as stagnant as ever. At Sheffield, however, a few branches of trade are still permitted to carry on by means of the gas and electric services, but the departments employed on the heavier classes of steel material are still marking time. In the case of the large steel smelters, even if ample coal supplies were available, it is extremely doubtful whether a restart could be made immediately, orders in this branch having steadily diminished of late owing probably to a lull in the issue of armament and shipbuilding contracts. The stagnation in overseas trade is unabated in intensity, as significantly exemplified in the recent Board of Trade Returns, showing a general reduction in tonnage. Special steels (including high-speed) declined from 1,200 tons to 395 tons, representing a money loss of £130,000. Railway material has had a set-back lately, the total for the month being only half what it was a year ago.

Metals.

Copper.—Movements in the market for this metal last week were characterised by only narrow fluctuations, the tone throughout continuing remarkably steady, with a moderate inquiry reported from the Continent. Conditions in this, as in other metal markets, have unquestionably been largely influenced by the labour situation, and with a return to a more hopeful prospect of something like permanent peace in the industrial world, the outlook should speedily show an improvement. The week's markets opened quiet with a moderate demand for standard, closing steady at £73 7s. 6d. cash and £73 7s. 6d. three months. Electrolytic, £77 to £79.

Tin.—During the past week greater variations in the values have occurred than in the case of other metals, and while the turnover has been larger than for some months previously, prices have steadily receded. At the opening, conditions were affected by heavy realisations and bear pressure, prices dropping to £166 cash and £167 5s. three months. A recovery followed, values advancing to £169 and £171 respectively on a strong demand. Selling pressure later induced a relapse, and the quotation declined to £166 cash and £167 10s. three months. Market values have remained steady this week, closing quotations marking £167 10s. with three months £169 10s. English ingots closed higher at £165 10s.

Spelter.—The market for this metal remains in a languid condition, but with a lack of offerings a firmer tone has developed, business being restricted to a few small parcels for June at £27 5s.

Lead.—With numerous selling orders in the market lead was on offer for June at £22 15s. to £22 10s., showing a decline of 12s. 6d. for soft foreign pig; July, £22 10s.; and September, £22 5s. to £22. English closed lower at £23 5s.

SUBSTITUTES REFUSE, OR YOU STAND TO LOSE. 3
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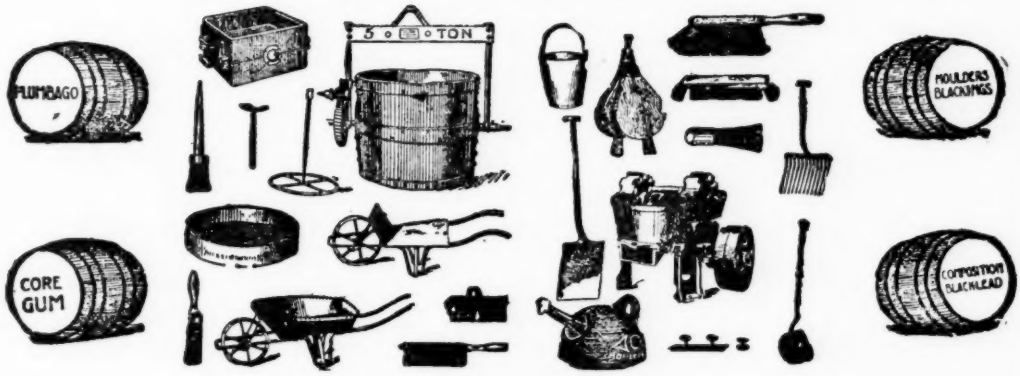
Write for Sample and Money-saving quotation to
BARTOLINE (HULL) LTD.,
OIL REFINERS, HULL.

Telephone: 21, Penistone. Telegrams: "Durrano, Penistone."

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



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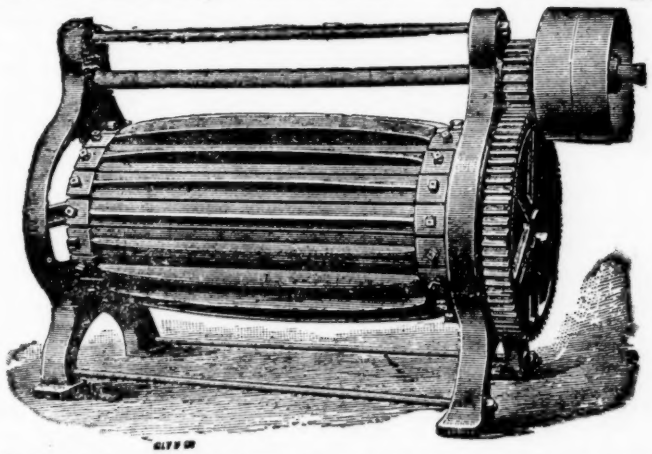
FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully. THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	73	7	6
Three months	73	7	6
Electrolytic	77	0	0
Tough	73	10	0
Best selected	74	0	0
Sheets	116	0	0
India	116	0	0
Wire bars	78	0	0
Do. July	79	0	0
Do. Aug.	79	0	0
Ingot bars	77	10	0
H.C. wire rods	84	0	0
Off. aver. cash, May	73	5	10½
Do. 3 mths., May	72	11	1
Do. Settlement May	73	5	2½
Do. Electro, May	74	15	8½
Do. B.S., May	74	1	8
Aver. spot, copper, May	73	5	2¾
Do. Electro, May	75	6	2½
Solid drawn tubes		15½d.	
Brazed tubes		15½d.	
Wire		12d.	
Yellow metal rods		8½d.	
Do. 4x4 Squares		10½d.	
Do. 4x3 Sheets		10½d	

BRASS.

Solid drawn tubes	13½d.
Brazed tubes	16½d
Rods	12½d.
Sheets to 10 w.g.	12d.
Wire	11½d.
Rolled metal	11½d.

TIN.

	£	s.	d.
Standard cash	167	10	0
Three Months	169	10	0
English	165	10	0
Bars	167	10	0
Chinese	163	0	0
Straits	167	10	0
Australian	168	0	0
Eastern	169	0	0
Banca	178	0	0
Off. aver., cash, May	177	10	8½
Do. 3 mths., May	178	19	10½
Do. Sttlment., May	177	9	0½
Aver. spot, May	177	8	4

SPELTER.

	£	s.	d.
Ordinary	27	0	0
Remelted	23	0	0
Hard	16	10	0
Electro 99.9	36	0	0
English	33	0	0
India	22	10	0
Prime Western	28	10	0
Zinc dust	50	0	0
Zinc ashes	6	0	0
Off. aver., May	27	6	7½
Aver., spot, May	26	18	5½

LEAD.

	£	s.	d.
Soft foreign ppt	22	5	0
English	23	5	0
Off. average, May	23	7	3½
Average spot, May	23	7	8½

ZINC SHEETS.

	£	s.	d.
Zinc sheets, spot	36	0	0
Do. V.M. ex. whf	36	0	0
Do. ppt., f.o.b., N.Y.		—	
Dutch	36	0	0
Boiler plates	33	0	0
Battery plates	32	10	0

ANTIMONY.

	£	s.	d.
English regulus	37	0	0
Special brands	42	0	0
Chinese	24	10	0
Crude	18	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	10	17	6

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
45/50%	16	0	0
75%	23	0	0
Ferro-vanadium—			
35/40%	22/- lb. va.		
Ferro-molybdenum—			
70/80%	7/6 lb. mo.		
Ferro-titanium—			
23/25%, carbonless	1/6 lb.		
Ferro-phosphorus, 20/23%	£29		
Ferro-tungsten—			
80/85%, carbon free	1/9 lb.		
Tungsten metal powder—			
98/99%	2/3 lb.		
Ferro-chrome—			
4/6% car.	£37	0	
6/8% car.	£36		
8/10% car.	£35	10	
Ferro-chrome—			
Max. 2% car.	£82		
Max. 1% car.	£98		
Max. 0.75% car.	£112		
65/75%, carbonless	2/9 lb.		
Nickel—99·8%, cubes or pellets	£185		
Cobalt metal—97%	15/- lb.		
Aluminium—98/99%	£150		
Metallic Chromium—			
98/99%	6/- lb.		
Ferro-manganese—			
76/80%, loose	£18		
76/80%, packed	£19		
76/80%, export	£15		
Metallic manganese—			
98/99%, carbonless	2/10 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten	3	0
Finished bars, 18% tungsten	3	9
Scrap pieces	5d.	
Turnings and swarf	3d.	

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. to 8 in. inclusive 4d. lb.

Rounds and squares under ½ in. to ¼ in. 3d. lb

Flats under 1 in. by ⅛ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness 3d. lb.

Bevels of approved sizes and sections 6d. lb.

If in coils 3d. lb.

Packing 4s. cwt

Bars cut to length 10% extra

Scrap from high-speed tool steel—

Scrap pieces 5d.

Turnings and swarf 3d.

Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—£ s. d.	£	s.	d.
Heavy Steel	3	5	0
Bundled steel & shearings	2	15	0
Mixed iron & steel 1 0 0	3	10	0
Heavy cast iron	3	15	0
Good machinery for foundries	5	10	0
Cleveland—			
Heavy steel	2	5	0
Steel turnings	2	7	6
Cast-iron borings	2	7	6
Heavy wrought iron piling	2	15	0
Bundling scrap	4	0	0
Cast-iron scrap	5	10	0
Lancashire—			
Cast iron scrap	6	0	0
Heavy wrought	3	0	0
Steel turnings	1	10	0
London—			
Copper (clean)	51	0	0
Brass (clean)	30	0	0
Lead (less usual draft)	18	10	0
Tea lead	16	10	0
Zinc	13	0	0
New aluminium cuttings	70	0	0
Brazier copper	41	0	0
Gun metal	45	0	0
Hollow pewter	135	0	0
Shaped black pewter	80	0	0

PIG-IRON.

N.-E. Coast—	
Foundry No. 1	125/-
Foundry No. 3	120/-
Forge No. 4	117/6
Mottled	117/6
Hematite No. 1	162/6
Hematite M/Nos.	160/-
Midlands—	
Staffs. common	145/-
,, part-mine forge	160/-
,, ,, foundry	170/-
,, Cold blast	320/-
,, basic	140/-
Northants forge	140/-
,, foundry No. 3	147/6
,, basic	140/-
Derbyshire forge	150/-
,, foundry No. 3	160/-
,, basic	150/-
Scotland—	
Foundry No. 1	170/-
,, No. 3	165/-
Hematite M/Nos.	180/-
Sheffield (d/d district)—	
Derby forge	155/-
,, foundry No. 3	160/-
,, basic	155/-
Lincs. forge	160/-
,, foundry No. 3	170/-
,, basic	162/6
E.C. hematite	173/-
W.C. hematite	176/-

All d/d in the district.

Lancashire (d/d eq. Man.)—	
Derby forge	—
,, foundry No. 3	170/-
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	172/6
,, foundry No. 3	177/6
Summerlee foundry	193/-
Glengarnock foundry	195/6
Gartsherrie foundry	193/-
Monkland foundry	193/-

FINISHED IRON & STEEL.

Iron—	£	s.	d.
Bars (cro'n)	19	0	0
Angles	19	10	0
Tees to 3 united ins.	20	0	0
Nut and bolt	19	0	0
Hoops	23	0	0
Marked bars (Staffs.)	27	10	0
Gas strip	22	0	0
Bolts and nuts, ¾ in. × 4 in.	38	0	0
Steel—			
Ship plates	19	0	0
Boiler plates	25	0	0
Chequer plates	20	0	0
Angles	17	10	0
Tees	18	10	0
Channels	18	0	0
Joists	17	10	0
Rounds, ⅝ in.–3-in.	14	0	0
Rounds, 3 in.–5½ in.	—		
Flats, 5 in.–8 in.	—		
Flats over 8 in.	—		
Rails, heavy	15	0	0
Fishplates	20	0	0
Hoops	16	10	0
Black sheets, 24 g.	19	10	0
Galv. cor. sheets, 24 g.	22	0	0
Galv. fencing wire, 8 g. plain	23	10	0
Rivets, ¾ in. dia	27	0	0
Billets, soft	11	10	0
Billets, hard	12	10	0
Sheet and tin bars	11	10	0

PHOSPHOR BRONZE.

ROLLED.	Per lb. s.	d.
½ in. to 1 in. wide	1	8½
1 in. to 1½ in. wide	1	8½
1½ in. to 2 in. wide	1	6½

STRIPS.	s.	d
2 in. to 6 in. to 26 S.W.G.	1	6½
6 in. to 12 in. to 26 S.W.G.	1	6½

SHEETS.	s.	d.
12 in. to 18 in. to 24 S.W.G.	1	6½
18 in. to 24 in. to 24 S.W.G.	1	7½
24 in. to 30 in. to 20 S.W.G.	1	8½
30 in. to 36 in. to 16 S.W.G.	1	9½
36 in. to 42 in. to 16 S.W.G.	1	9½

EXTRAS.

FOR GAUGE: Any width up to 36 in. wide, ½d. per lb. per thinner gauge.

DRAWN RODS.	s.	d.
¼ in. to ½ in. dia. in random lengths; ⅝ in. to 1½ in. dia. in random lengths	1	6
Over 1½ in. to 1¾ in.	1	6
Tubes—basis price	1	8½

Delivery 2 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

CHARLES CLIFFORD & SON, LIMITED, BIRMINGHAM.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	1/1 to 1/7
Rolled—	
To 9 in. wide	1/8½ to 2/2½
To 12 in. wide	1/9 to 2/3
To 15 in. wide	1/10 to 2/4
To 18 in. wide	1/11 to 2/5
To 21 in. wide	2/- to 2/6
To 24 in. wide	2/1 to 2/7
Ingots for spoons and forks	1/1 to 1/7
Ingots rolled to spoon size	1/4 to 1/10
Wire round—	
3/0 to 10. G.	1/11 to 2/6

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	25.50
No. 2 foundry Valley	23.00
No. 2 foundry, Birm.	20.00
Basic	23.71
Bessemer	24.96
Malleable	25.96
Grey forge	23.96
Ferro-manganese 80 % delievred	85.00
Bess. rails, h'y, at mill	45.00
O.-h. rails, h'y, at mill	47.00
Bess. billets	37.00
O.-h. billets	37.00
O.-h. sheet bars	39.00
Wire rods	48.00
	Cents.
Iron bars, Phila.	2.25
Steel bars	2.10
Tank plates	2.20
Beams, etc.	2.20
Skelp, grooved steel	2.20
Skelp, sheared steel	2.20
Steel hoops	2.75
Sheets, black, No. 28	4.00
Sheets, galv., No. 28	5.00
Sheets, blue an'l'd, 9&10	3.10
Wire nails	3.25
Plain wire	3.00
Barbed wire, galv.	4.10
Tinplate, 100-lb. box	$6.25

COKE.

Welsh foundry	67/6
,, furnace	55/-
Durham & North. foundry	70/-
,, furnace	42/6
Other Districts, foundry	77/9
,, furnace	45/-

SWEDISH IRON.

Bars, hammered basis sizes	Basis price £31 to £32
Rolled Ordinary— Assortment ..	£ s. d. 22 10 0 to 23 10 0
Nail Rods— Square, round and flats ..	
Keg Steel	.. £38 to £40
Faggot Steel	.. £30 to £32
Blooms— Single welded	.. £16 to £18
Billets— Single and double welded	.. £18 to £23
Pig-Iron— Grey, white or mottled	£10/10 to £11 10

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

	Up to and incl. 2 in.	Over 2 in.
Gas .	−15%	−20%
Water ..	− 5%	−11¼%
Steam ..	+ 6¼%	− 1¼%

TINPLATES.

I.C. Cokes,	20×14, box	25/6
„	28×20, „	51/-
„	20×10, „	35/-
„	18¾×14, „	29/-
I.X.	„	64/-
I.X.X.	„	84/-
F.C.B.Y.	21×13⅝ „	48/6
C.V.B.G.	16⅓×15, „	49/-
I.C.W.	20×14, „	20/-
„	28×20, „	40/-
„	20×10, „	29/-
„	18¾×14, „	17/9
Terneplates,	28×20, „	50/-

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
June 8	73	17	6	inc.	22/6
„ 9	73	10	0	dec.	7/6
„ 10	73	0	0	„	10/-
„ 13	73	2	6	inc.	2/6
„ 14	73	7	6	„	5/-

Electrolytic Copper

June 8	76	0	0	No change	
„ 9	77	0	0	inc.	20/-
„ 10	77	0	0	No change	
„ 13	77	0	0	No change	
„ 14	77	0	0	„	

Standard Tin (cash).

June 8	167	10	0	inc.	35/-
„ 9	168	15	0	„	25/-
„ 10	165	15	0	dec.	60/-
„ 13	167	0	0	inc.	25/-
„ 14	167	10	0	inc.	10/-

Tin (English Ingots)

June 8	165	0	0	inc.	40/-
June 9	167	0	0	inc.	40/-
„ 10	164	0	0	dec.	60/-
„ 13	165	0	0	inc.	20/-
„ 14	167	10	0	„	50/-

Zinc Sheets (spot).

June 8	36	0	0	No change
„ 9	36	0	0	No change
„ 10	36	0	0	No change
„ 13	36	0	0	No change
„ 14	36	0	0	No change

Spelter (ordinary).

June 8	26	15	0	inc.	5/-
„ 9	27	0	0	„	5/-
„ 10	27	5	0	„	5/-
„ 13	27	5	0	No change	
„ 14	27	0	0	dec.	5/-

Lead (English).

June 8	24	0	0	inc.	5/-
„ 9	24	10	0	„	10/-
„ 10	24	5	0	dec.	5/-
„ 13	23	15	0	„	10/-
„ 14	23	5	0	„	10/-

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Five LANCASHIRE BOILERS, 30 ft. x 7 ft. 6 in., now insured at 160 lbs pressure.

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